IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appellant:	LOT 3 ACQUISITION FOUNDATION, LLC
Serial No.:	09/823,509
Filing Date:	March 29, 2001
Title:	OBJECT LOCATION INFORMATION
Examiner:	Tung T. Vo
Art Unit:	2621
Conf. No.:	8530
Attorney Docket No.:	84022.0137

TO: Mail Stop APPEAL BRIEF-PATENTS
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

APPELLANT'S BRIEF PURSUANT TO 37 C.F.R. § 41.37

Dear Commissioner,

Appellant appeals the decision of the Examiner finally rejecting all pending claims 24-33 and 39-53 in the subject patent application and files this appeal brief under 37 C.F.R. § 41.37 within two months from the date of filing the Notice of Appeal under § 41.31.

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I. REAL PARTY IN INTEREST

The subject patent application was assigned by inventor Irene V. Hu to Fernandez & Associates, LLP on June 8, 2004. This assignment was recorded on August 3, 2004 at Reel/Frame 015649/0423. A corrective assignment by inventor Irene V. Hu to co-inventor Dennis S. Fernandez was executed on June 8, 2004. This assignment was recorded on August 8, 2005 at Reel/Frame 016343/0986. The subject patent application was assigned by Dennis S. Fernandez to Lot 3 Acquisition Foundation, LLC on May 16, 2007. This assignment was recorded on July 3, 2007 at Reel/Frame 019515/0553. Therefore, Lot 3 Acquisition Foundation, LLC is the real party in interest in the subject patent application.

II. RELATED APPEALS AND INTERFERENCES

Prior to acquisition of the present application by Lot 3 Acquisition Foundation, LLC, a Notice of Appeal was filed August 24, 2006, and an amended Appeal Brief was filed November 17, 2006 in the present application. However, the Examiner reopened prosecution in an Office Action dated March 12, 2007, so the appeal was not instituted. Thus, there are no related appeals and interferences.

III. STATUS OF CLAIMS

Claims 24-33 and 39-53 are pending in the application, of which claims 24 and 31 are independent claims. Claims 24-33 and 39-53 are rejected under 35 U.S.C. § 103(a). Claims 1-23 and 34-38 were previously cancelled. All claims 24-33 and 39-53 are being appealed.

IV. STATUS OF AMENDMENTS

No amendments were presented in reply to the Final Office Action dated November 19, 2009. Thus, the claims in the Claims Appendix represent the claims Appellant believes to be currently pending.

V. SUMMARY OF CLAIMED SUBJECT MATTER

Independent claim 24 is directed to a system that comprises "a communicator"[1] that receives "first data"[2] and "second data"[3] associated with an "object."[4] The first data is received from a "fixed detector,"[5] and the second data is received from a "mobile target unit."[6] The mobile target unit comprises a sensor that detects the second data.[7] The mobile target unit "is at least one of: mounted in the object, mounted on the object, carried in the object, or carried on the object."[8] The system further comprises "a processor"[9] that correlates the first data and the second data to generate "object location information."[10]

Independent claim 31[11] is directed to a method that comprises receiving first data from a fixed detector and second data from a mobile target unit. The first data and second data are associated with an object. The mobile target unit is mounted in, mounted on, and/or carried on the object. The first data and the second data are correlated to generate object location information.

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[1] See, e.g., p. 3, line 7 through p. 6, line 5; p. 8, lines 22-30; p. 12, lines 8-12; and FIGS. 1, 3. Citations are to page and line numbers from the application as filed for Serial No. 09/823,509.
[2] See, e.g., p. 7, line 1 through p. 8, line 4; p. 8, lines 22-30; p. 9, lines 9-18; p. 10, line 7 through p. 11 line 27; p. 18, line 17 through p. 19, line 19; p. 29, line 17 through p. 32, line 26; and p. 33, line 27 through p. 35, line 12.
[3] See, e.g., p. 7, line 1 through p. 8, line 4; p. 8, line 22 through p. 9, line 18; p. 10, line 7 through p. 11 line 27; p. 18, line 17 through p. 19, line 19; p. 29, line 17 through p. 32, line 26; and p. 33, line 27 through p. 35, line 12.
[4] See, e.g., p. 2, lines 3-15; p. 3, lines 12-19; p. 11, line 18 through p. 12, line 6; p. 17, lines 1-8; p. 19, lines 21-29; p. 23, line 25 through p. 25, line 28; and p. 26, line 24 through p. 27, line 17.
[5] See, e.g., p. 5, line 27 through p. 8, line 30; p. 27, lines 1-17; p. 28, lines 4-15; p. 30, line 4 through p. 31, line 10; and p. 34, lines 24-29.
[6] See, e.g., p. 5, line 27 through p. 6, line 29; p. 9, lines 1-5; p. 27, lines 1-17; p. 35, lines 1-8; and FIGS. 1-2.
[7] See, e.g., p. 5, line 27 through p. 6, line 29; p. 9, lines 1-5; p. 27, lines 1-17; p. 35, lines 1-8; and FIGS. 1-2.
[8] See, e.g., p. 9, lines 1-18; p. 11, line 29 through p. 12, line 12; and p. 13, lines 9-16.
[9] See, e.g., p. 3, line 2 through p. 6, line 5; p. 9, lines 20-27; p. 10, line 17 through p. 11, line 20; p. 13, line 24 through p. 14, line 22; and FIGS. 2-3.
[10] See, e.g., p. 10, line 17 through p. 11, line 20; p. 18 line 17 through p. 21, line 20; p. 22, lines 7-13; p. 29, line 17 through p. 32, line 26; p. 33, line 1 through p. 35, line 8; and FIG. 4.

No means plus function or step plus function claims under 35 U.S.C. § 112, sixth paragraph are being appealed.

[11] See, e.g., FIG. 4 and support for similar elements shown with respect to claim 24 listed above.

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

A. Whether claims 24-32, 39-40, and 42-50 are unpatentable under 35 U.S.C. § 103(a) over Everett, Jr., et al., U.S. Patent No. 5,202,661 ("Everett") in view of Hyuga, U.S. Patent No. 5,818,733 ("Hyuga").

B. Whether claims 24-33 and 39-53 are unpatentable under 35 U.S.C. § 103(a) over Moengen, U.S. Patent No. 6,373,508 ("Moengen").

C. Whether claim 41 is unpatentable under 35 U.S.C. § 103(a) over Everett, in view of Hyuga and Kitamura, et al., U.S. Patent No. 5,554,983 ("Kitamura").

VII. ARGUMENT

Appellant respectfully requests that the Board reverse the Examiner's 35 U.S.C. § 103(a) rejections.

A. Rejections under 35 U.S.C. § 103(a) over Everett in view of Hyuga

Appellant addresses individual claims below, but initially, Appellant notes that "[t]he mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination." M.P.E.P. § 2143.01(III) (emphasis in original). In fact, Appellant submits that Hyuga ***cannot*** and should not be combined with Everett in the manner the Examiner suggests. In this regard, Appellant reiterates that "[i]f proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, ***then there is no suggestion or motivation*** to make the proposed modification." M.P.E.P. § 2143.01(V) (emphasis added). Thus, it is significant that the modification the Examiner proposes from Hyuga would render Everett unsatisfactory for its intended purpose.

Specifically, Appellant's argument with respect to the combination of Everett and Hyuga can be outlined as follows:

1. A secondary reference is not combinable with a primary reference if the proposed modification to the primary reference, using the secondary reference, would render the primary reference unsatisfactory for its intended purpose. *See* M.P.E.P. § 2143.01(V).

2. The Examiner suggests modifying Everett such that the intruder, of which Everett's surveillance system monitors, carries the mobile target unit as disclosed in Hyuga, but this modification clearly renders Everett unsatisfactory for its intended

purpose (as will be discussed further below) -- how could an intruder be expected to carry part of the surveillance system intended to detect his unauthorized presence?

3. Because Hyuga would render Everett unsatisfactory for Everett's intended purpose, Hyuga is not combinable with Everett, and Appellant respectfully requests withdrawal of all rejections based on the combination of Everett and Hyuga

1. *Claims 24-26, 28, 30-32, 39-40, and 42-50*

Everett discloses a "system for detecting intrusion into a secured environment using both fixed and mobile intrusion detectors . . . The mobile sensors are mounted on one or more mobile platforms which selectively patrol throughout the environment and may be rapidly deployed to any region in the environment where a fixed intrusion detector detects a possible intrusion" (Abstract). "The sensor suite onboard the mobile robot contains multiple, high resolution sensors of different types that are automatically oriented towards the potential intruder" (Everett, column 2, lines 31-34).

The following table illustrates some elements of Appellant's claims[12] which the Examiner asserts[13] read on Everett.

Claim 31	***Everett***
fixed detector	"fixed sensor system, 12 of fig. 1"
object	intruder
first data associated with the object	presence of the intruder
mobile target unit	"mobile sensor, 19 of fig. 2"
second data	presence of the intruder

[12] Claim 31 is used for illustration purposes. Similar elements may be found in claim 24.
[13] Quotations regarding Everett are from the Final Office Action, Nov. 19, 2009, pages 2-3.

With reference to this table, it becomes abundantly clear that Everett cannot disclose or contemplate each element of Appellant's claims, regardless of what reference is combined with Everett. Specifically, Appellant claims "wherein the mobile target unit is at least one of: mounted in the object, mounted on the object, carried in the object, or carried on the object" (claim 31). Rewording this element using the table above results in "wherein the [mobile sensor] is at least one of: mounted in the [intruder], mounted on the [intruder], or carried on the [intruder]."

Appellant's respectfully assert that the Examiner's rationale for this reading of claims is perplexing to say the least. How can an intruder be expected to carry (in himself or on himself) the very object that is secretly detecting his presence? Would a security guard hand the intruder the mobile sensor when the intruder illegally enters the building? In any case, Everett's intruder could simply dispose of the sensor, thus rendering Everett's system inoperable.

These questions highlight Appellant's arguments that Appellant's claims are not obvious in light of the combination of Everett and Hyuga. For a claim to be obvious in light of a reference or combination of references, there must be some motivation to combine the references or make the suggested modification.[14] Otherwise, one of skill in the art would not look to the reference or combination of references to make the suggested modification.

Here, no one of skill in the art would look to Everett when developing a system where an object being detected actually carries part of the detection system. One of skill in the art would know that an intruder could not be expected to carry a sensor that would give away his intrusion. For these reasons, Everett ***teaches against*** "wherein the mobile target unit is at least one of: mounted in the object, mounted on the object, carried in the object or carried on the object" as

recited in claim 31, and as similarly recited in claim 24. In fact, modifying Everett in this manner would render Everett unsatisfactory for its intended purpose.[15]

Thus, there is no motivation to modify Everett in this manner, regardless of what reference discloses a sensor carried by a sensed object. Even though Hyuga may disclose that an "on-vehicle imaging device 27c may be placed atop a golf cart 29" (Hyuga, column 5, lines 6-8), there is no suggestion or motivation to combine Hyuga -- ***or any other reference*** -- with Everett in the manner suggested by the Examiner. Therefore, regardless of what Hyuga discloses,[16] Everett cannot disclose or contemplate, alone or in combination with Hyuga, "wherein the mobile target unit is at least one of: mounted in the object, mounted on the object, carried in the object or carried on the object" as recited in claim 31, and as similarly recited in claim 24. Thus, Appellant respectfully requests that the Board reverse the rejections of claims 24 and 31 based on Everett.

Claims 25-26, 28, 30, 32, 39-40, and 42-50 variously depend from independent claims 24 and 31. Therefore, Appellant asserts that dependent claims 25-26, 28, 30, 32, 39-40, and 42-50 are differentiated from the cited references for at least the same reasons stated above for

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[14] "The mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination." M.P.E.P. § 2143.01(III) (emphasis in original).

[15] "If proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, ***then there is no suggestion or motivation*** to make the proposed modification." M.P.E.P. § 2143.01(V) (emphasis added).

[16] Hyuga generally discloses a group of cameras at a location (e.g., a golf course) where each of the cameras are capable of recording an image of an object (e.g., golfer) located in a particular section of the location (e.g., at the ninth hole green). One of the cameras is selected from a known, current location of the object being observed: "Based on the locational signals from receiver (21), camera controller component (26) selects camera (27i) ~ (27n), (27c) and controls panning and tilting of the selected camera" (Abstract). The location of the object is known, for example, by a signal from a "mobile unit which is in the possession of each [golf] player or caddie . . . [which] transmits signals revealing its location" (Hyuga, column 4, lines 14-36). "Therefore, according to the invention, it is easy to know the location of the sender of the signals and take his picture with an imaging device" (column 2, lines 7-9). Once the system in Hyuga determines an actual location of the object to be monitored, a camera in the actual location is selected to record an image of the object—i.e., the golfer.

differentiating independent claims 24 and 31, as well as in view of their own respective features. Appellant thus requests that the Board reverse the Examiner's rejection of claims 25-26, 28, 30, 32, 39-40, and 42-50.

2. Claim 27

Neither Everett, nor Hyuga, alone or in combination, discloses or contemplates "wherein the object is a vehicle" as recited in claim 27. The object Everett senses is an intruder (Everett, Abstract), and Everett does not disclose that the intruder can be a vehicle. Rather, the Examiner asserts "the ***mobile target unit*** includes a vehicle" (Final Office Action, Nov. 19, 2009, page 3; emphasis added). But at the same time, the Examiner admits that the "object" in Appellant's claims is the intruder (see the table listed above). The Examiner appears to argue that the single "object" in Appellant's claims reads on both Everett's intruder ***and*** mobile target unit. Appellant respectfully submits that this claim construction is erroneous. Nowhere does Everett disclose or contemplate that the intruder is a vehicle.

Similarly, although Hyuga discloses that an "on-vehicle imaging device 27c may be placed atop a golf cart 29" (Hyuga, column 5, lines 6-8), the "golf cart" is not the object being imaged. Rather, the imaging device captures an image of the golfer (Hyuga, column 7, lines 1-32). For at least these reasons, neither Hyuga nor Everett, alone or in combination, disclose or contemplate "wherein ***the object*** is a vehicle" as recited in claim 27 (emphasis added). Appellant therefore respectfully requests the Board reverse the rejection of claim 27.

3. Claim 29

Neither Everett nor Hyuga disclose or contemplate an "accelerometer" as recited in claim 29. The Examiner merely shows the existence of a "processor" in Everett and asserts that "velocity control and acceleration/deceleration ramping are performed by processor 417" (Final

Office Action, page 5). In contrast, Appellant respectfully submits that there is a significant distinction between an "accelerometer" and a processor that instructs an object to accelerate. For example, a gas pedal in a car instructs a car to accelerate, but a gas pedal is not an accelerometer. Therefore, Appellant respectfully requests that the Board reverse the rejection of claim 29.

B. Rejection under 35 U.S.C. § 103(a) over Moengen

1. Claims 24-26, 28-33, 39-40, and 42-53

Moengen discloses "a method for manipulation of a movable object displayed in a television picture, [where] the distance between the object and fixed basic positions is detected at a time t together with the distance between the object and a television camera in a ***known*** position" (Abstract; emphasis added). "Both the position detectors [D] and the television cameras [K] are positioned in a ***pre selected x,y,z coordinate system*** . . . The positions of both the position detectors [D] and the cameras [K] ***are precisely defined*** in the x,y,z co-ordinate system" (Moengen, column 5, lines 51-59; emphasis added).

"Where mobile cameras . . . are used, it will be possible to determine the ***camera positions*** by means of the position detectors [D]" (column 12, lines 28-31; emphasis added). "[T]he position ***of a mobile camera*** . . . is determined by means of GPS and transferred to the production location" (column 16, lines 17-20). "Four position detectors [D] are preferably used to achieve unambiguous detection of the position of the natural object N. The position ***of the object N*** is thereby ***<u>solely</u>*** determined by ***<u>distance</u>*** measurements, i.e. by trilateration" (column 6, lines 39-43; emphasis added). "The detected distances are given to a computing module 2 which by means of trilateration calculates the positions x,y,z at different times t and thereby also the path of the object N ***on the basis of positions detected*** at the different times t" (column 7, lines 4-8; emphasis added).

Because "the position of [Moengen's] object N is . . . ***solely*** determined by distance measurements [of fixed position detectors D]" (column 6, lines 39-43; emphasis added) (see also column 5, lines 51-59), Moengen does not disclose or contemplate, alone or in combination with any of the cited references, "a processor configured to correlate the first data [from the fixed detector] ***and*** the second data [from the mobile target unit] to generate object location information" as recited in claim 24 (emphasis added), and as similarly recited in claim 31.

The Examiner asserts "the second data is received from a mobile target unit (note the mobile camera is used . . .)" (Final Office Action, page 7). Regardless of whether or not Moengen's camera receives "second data," it is clear from Moengen that nothing from Moengen's camera is used to "generate object location information." Moengen explicitly states, "the position of [Moengen's] object N is . . . ***solely*** determined by distance measurements" (Moengen, column 6, lines 39-43; emphasis added), which explicitly excludes using any image data received through the cameras to determine position or location. Appellant therefore respectfully requests that the Board reverse the Examiner's rejections of claims 24 and 31.

Claims 25-26, 28-30, 32-33, 39-40, and 42-53 variously depend from independent claims 24 and 31. Therefore, Appellant asserts that dependent claims 25-26, 28-30, 32-33, 39-40, and 42-53 are differentiated from the cited references for at least the same reasons stated above for differentiating independent claims 24 and 31, as well as in view of their own respective features. Appellant thus requests that the Board reverse the Examiner's rejection of claims 25-26, 28-30, 32-33, 39-40, and 42-53.

2. Claim 27

The Examiner argues that "Moengen further teaches the object is a vehicle . . . and the mobile target unit . . . [is] at least one of: mounted in the object, mounted on the object, carried in

the object, or carried on the object" (Final Office Action, page 8). However, nowhere does Moengen disclose or contemplate "wherein the mobile target unit is at least one of: mounted in the object, mounted on the object, carried in the object, or carried on the object" as recited in claim 31, and as similarly recited in claim 24.

Moengen simply refers to a possibility of using a mobile camera (see, e.g., Moengen, column 12, lines 28-31), but does not refer to the mobile camera being mounted in/on or carried in/on the object being monitored. In fact, all other cameras in Moengen are disclosed to ***not*** be mounted in/on or carried in/on the object being monitored (see, e.g., FIGS. 1 and 8). Therefore, there is no suggestion in Moengen that these mobile cameras would be mounted in/on or carried in/on the object being monitored (in fact, Moengen suggests the opposite). Appellant therefore respectfully requests that the Board reverse the Examiner's rejection of claim 27.

3. Claim 41

Moengen discloses an "object vector" and a "camera vector" (see Moengen, column 5, line 67 through column 6, line 11), but neither of these vectors is a "movement vector" as recited in Appellant's claim 41. For example, the "picture axis or the optical axis in a camera K is represented by a vector called the camera vector" (column 5, line 67 through column 6, line 2), and the "connecting line between the lens centre in a camera K and the object N . . . is called the object vector" (Moengen, column 6, lines 12-14). These vectors are used to determine a ***current*** position of the natural object[17] so that a "synthetic track can be generated in a television picture, the synthetic track thus being intended to represent the path of a natural object N in the television picture during a given period" (column 14, lines 12-16). Thus these vectors are not "movement

[17] "The data processing unit Q also comprises a manipulator module 4 for generating a synthetic object S which corresponds to the natural object N . . . Thus in the position X, Y in the camera's picture plane, via, e.g., a video generator . . . a synthetic object can be created, representing the natural object N ***in its position X, Y*** in the picture plane in the camera K" (Moengen, column 7, lines 31-41; emphasis added).

vectors," but are simply vectors that relate a current position of the natural object to a vector associated with a camera.

Furthermore, the data from the camera vectors and object vectors are used to generate this synthetic path that the natural object ***has already traveled***: "[t]he primary object here is that the synthetic object S which represents the natural object N should at all times display the position and/or the movement of the natural object N, ***as it would be represented*** in the television picture ***at any time t***" (Moengen, column 7, lines 43-47; emphasis added). Therefore, Moengen does not disclose or contemplate "determining a movement vector to ***predict*** a ***future location*** of the object" as recited in claim 41 (emphasis added). Appellant therefore respectfully requests that the Board reverse the Examiner's rejection of claim 41.

C. Rejection under 35 U.S.C. § 103(a) over Everett in view of Hyuga and Kitamura

Claim 41 depends from independent claim 31. Therefore, Appellant asserts that dependent claim 41 is differentiated from the cited references for at least the same reasons stated above for differentiating independent claim 31, as well as in view of its own features. Appellant thus requests that the Board reverse the Examiner's rejection of claim 41.

D. Conclusion

In conclusion, Appellant respectfully requests that the Board reverse the Examiner's 35 U.S.C. § 103(a) rejections of all pending claims 24-33 and 39-53.

Respectfully submitted,

Dated: April 2, 2010

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VIII. CLAIMS APPENDIX

1-23. (Canceled)

24. (Rejected) A system comprising:

a communicator configured to receive first data associated with an object and second data associated with the object, wherein the first data is received from a fixed detector configured to detect the first data, and wherein the second data is received from a mobile target unit comprising a sensor configured to detect the second data, wherein the mobile target unit is at least one of: mounted in the object, mounted on the object, carried in the object, or carried on the object; and

a processor configured to correlate the first data and the second data to generate object location information.

25. (Rejected) The system of Claim 24 wherein the communicator is further configured to receive a target unit location, the processor being further configured to determine whether the mobile target unit is within a range of the fixed detector.

26. (Rejected) The system of Claim 24 wherein:

the object location information comprises at least one of object trajectory information, object physical location information, or object speed information; and

the fixed detector is configured to provide an image of the object.

27. (Rejected) The system of Claim 24 wherein the object is a vehicle.

28. (Rejected) The system of Claim 24, further comprising a database configured to maintain a plurality of current positions associated with at least one of a plurality of sensors, a plurality of mobile target units, or a plurality of objects.

29. (Rejected) The system of Claim 24 wherein the mobile target unit comprises an accelerometer configured to provide data indicative of movement of the object to facilitate generating the object location information.

30. (Rejected) The system of Claim 24 wherein:

the object is an identified good;

the mobile target unit comprises a radio-frequency identification device; and

the fixed detector comprises a camera for observing the identified good, to facilitate enabling the sensor and the fixed detector to provide corroborative surveillance of the identified good.

31. (Rejected) A method comprising:

receiving, from a fixed detector, first data associated with an object;

receiving, from a mobile target unit, second data associated with the object, wherein the mobile target unit comprises a sensor configured to detect the second data, and wherein the mobile target unit is at least one of: mounted in the object, mounted on the object, carried in the object, or carried on the object; and

correlating the first data and the second data to generate object location information.

32. (Rejected) The method of Claim 31, further comprising activating a second fixed detector in response to the object location information.

33. (Rejected) The method of Claim 31 wherein the second data comprises an object identifier, the method further comprising registering the object identifier in a database to indicate association with the object.

34-38. (Canceled).

39. (Rejected) The system of Claim 24 wherein the second data comprises the target unit location.

40. (Rejected) The method of Claim 31, wherein the correlating the first data and the second data comprises determining compliance with a scheduled object activity.

41. (Rejected) The method of Claim 31, wherein the correlating the first data and the second data comprises determining a movement vector to predict a future location of the object.

42. (Rejected) The system of Claim 24 further comprising a plurality of detectors each having a corresponding observation range, wherein at least one of the plurality of detectors is selected to observe the object.

43. (Rejected) The system of Claim 24 wherein the first data comprises at least one of an image of the object or an identifier associated with the object.

44. (Rejected) The system of Claim 24 wherein the first data comprises a plurality of images of the object captured at different times.

45. (Rejected) The system of Claim 24 wherein the second data comprises at least one of an image of the object or an identifier associated with the object.

46. (Rejected) The system of Claim 24 wherein the second data comprises a plurality of images of the object captured at different times.

47. (Rejected) The system of Claim 24 wherein the object location information is determined at least in part based on a fixed detector location.

48. (Rejected) The system of Claim 24 wherein the object location information is determined at least in part based on a mobile target unit location.

49. (Rejected) The system of Claim 24, further comprising a movement module configured to activate a second fixed detector in response to the object location information.

50. (Rejected) The method of Claim 31, wherein correlating the first data and the second data to generate object location information comprises determining at least one of a trajectory or a speed of the object.

51. (Rejected) The system of Claim 24, wherein the mobile target unit comprises a locator unit configured to determine the target unit location.

52. (Rejected) The system of Claim 24, wherein the fixed detector is configured to be selected in response to the processor's correlation of the first data and the second data.

53. (Rejected) The system of Claim 49, wherein the fixed detector is further from the second fixed detector than from a third fixed detector.

IX. EVIDENCE APPENDIX

Copies of:

Everett, Jr., et al., U.S. Patent No. 5,202,661

Hyuga, U.S. Patent No. 5,818,733

Moengen, U.S. Patent No. 6,373,508

Kitamura, et al., U.S. Patent No. 5,554,983

M.P.E.P. § 2143.01(III), (V)

Final Office Action, November 19, 2009

United States Patent [19]

Everett, Jr. et al.

[11] Patent Number: 5,202,661
[45] Date of Patent: Apr. 13, 1993

[54] METHOD AND SYSTEM FOR FUSING DATA FROM FIXED AND MOBILE SECURITY SENSORS

[75] Inventors: Hobart R. Everett, Jr.; Gary A. Gilbreath, both of San Diego, Calif.

[73] Assignee: The United States of America as represented by the Secretary of the Navy, Washington, D.C.

[21] Appl. No.: 697,128

[22] Filed: Apr. 18, 1991

[51] Int. Cl.^{5} G08B 19/00
[52] U.S. Cl. 340/522; 340/565; 340/531; 340/539; 901/1
[58] Field of Search 340/522, 506, 511, 507, 340/539, 531, 825.06, 825.69, 565; 901/1, 49, 50, 46; 358/108, 110, 112, 113; 364/424.02; 318/568.12; 180/169

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OTHER PUBLICATIONS

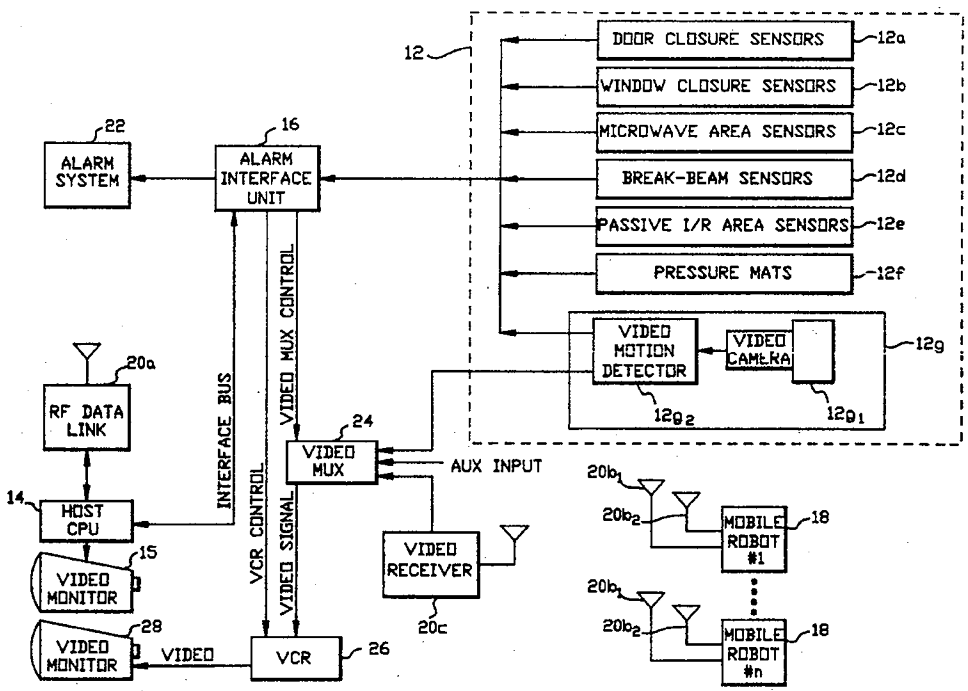
"Development of a Mobile Robot for Security Guard" by Kajiwara, et al. Nov. 1984.

Primary Examiner—Jin F. Ng
Assistant Examiner—Christine K. Oda
Attorney, Agent, or Firm—Harvey Fendelman; Thomas Glenn Keough; Michael A. Kagan

[57] **ABSTRACT**

A system for detecting intrusion into a secured environment using both fixed and mobile intrusion detectors includes a multiplicity of fixed intrusion detection sensors are each deployed at specific, fixed locations within the environment. The mobile sensors are mounted on one or more mobile platforms which selectively patrol throughout the environment and may be rapidly deployed to any region in the environment where a fixed intrusion detector detects a possible intrusion. A computer receives the outputs of the fixed and mobile sensors and is communicatively coupled to the mobile platforms. The computer directs the mobile platforms to travel through the environment along paths calculated by the computer, calculates a sum of weighting factors associated with the output of each sensor, and fuses the sensor outputs so that the sum is uninfluenced by the traveling of the mobile platforms. The sum is compared to a reference whereby an output is provided when the sum exceeds the reference. An alarm system operably coupled to the computer provides an intrusion alert when the output received exceeds the reference.

11 Claims, 31 Drawing Sheets



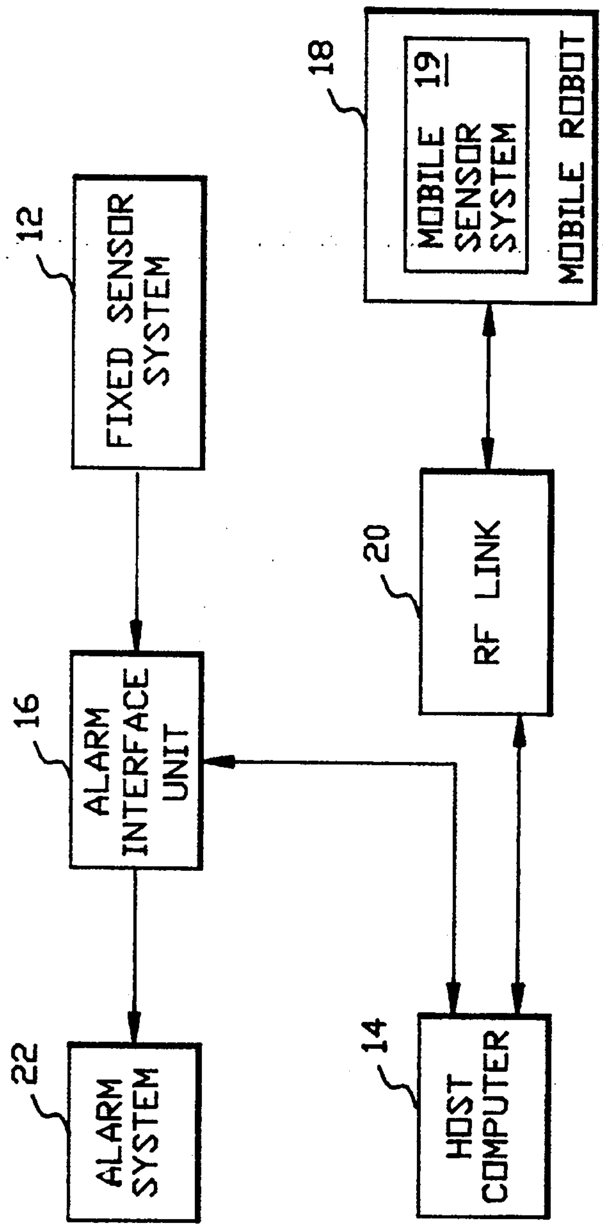

12
FIXED SENSOR SYSTEM
18
MOBILE 19
SENSOR
SYSTEM
MOBILE ROBOT
16
ALARM
INTERFACE
UNIT
20
RF LINK
22
ALARM
SYSTEM
14
HOST
COMPUTER

FIG. 1

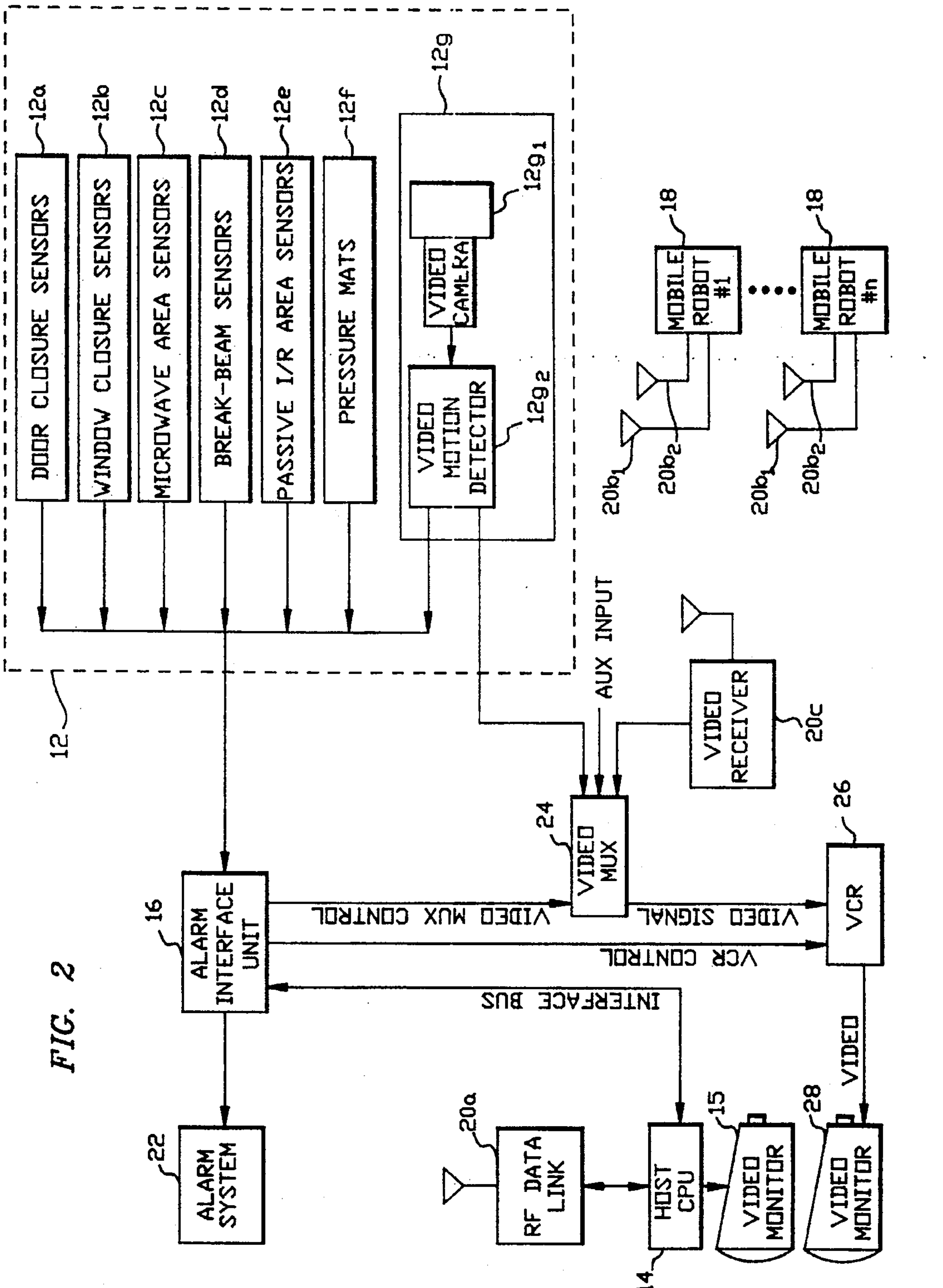
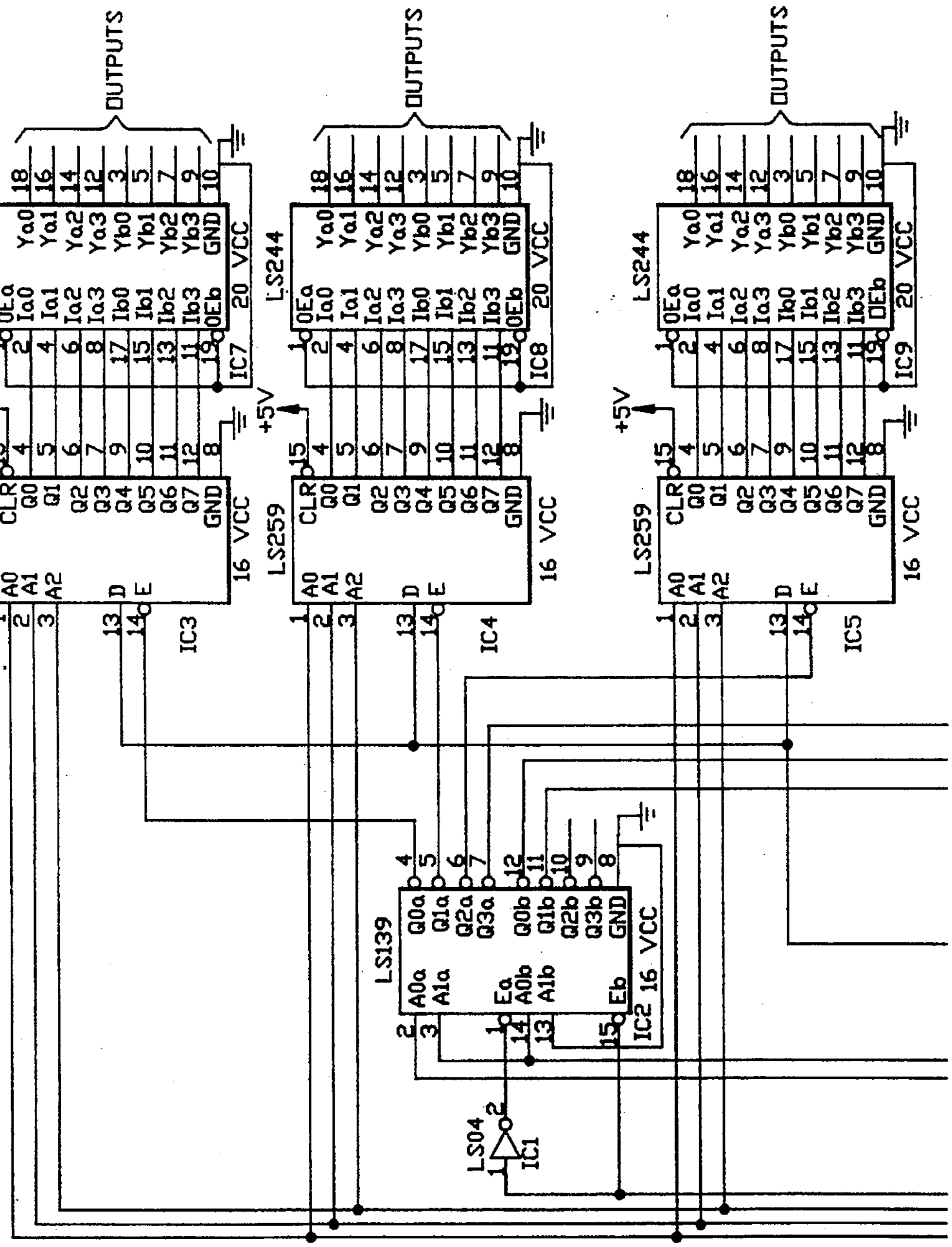
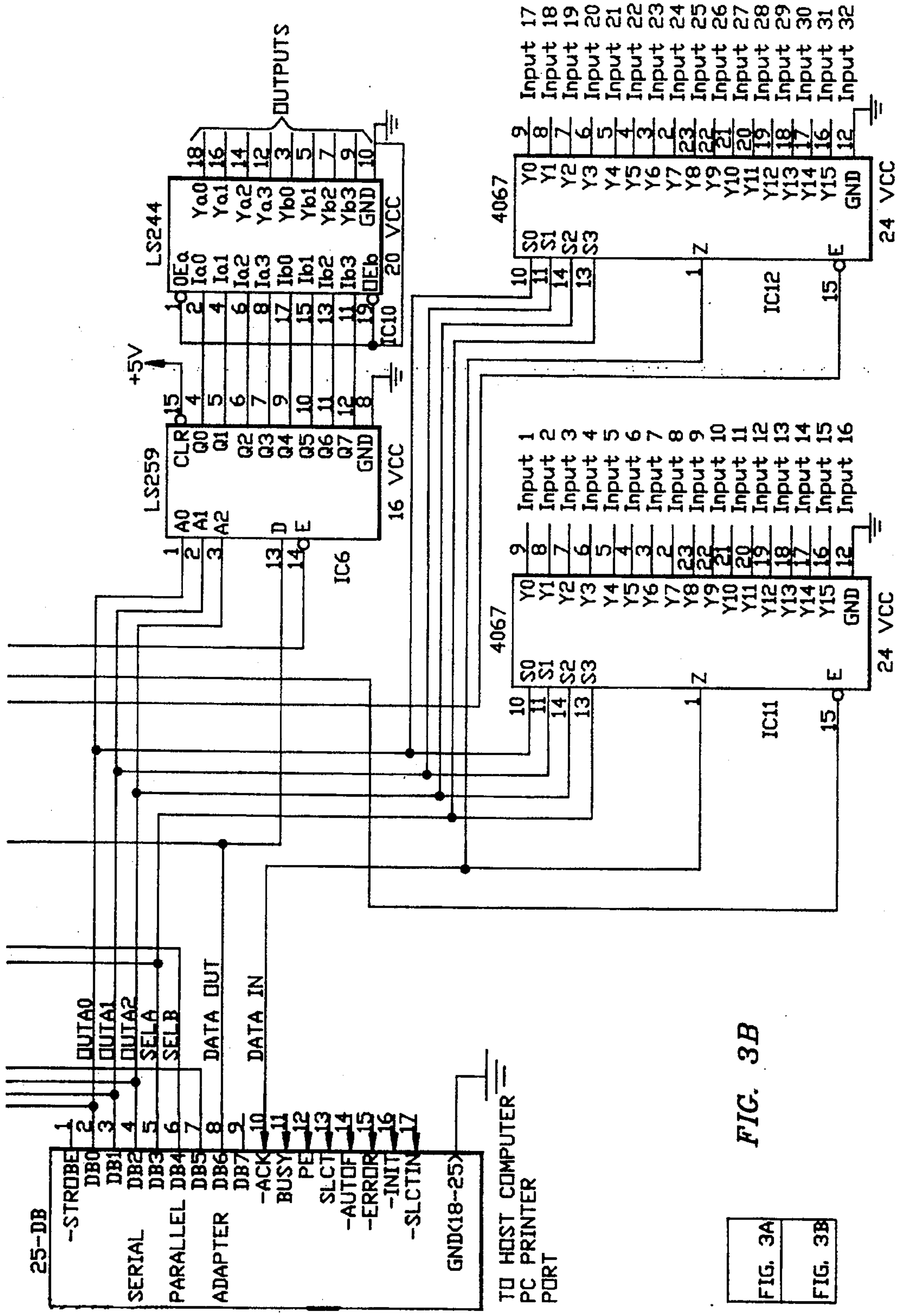

DOOR CLOSURE SENSORS
12a
WINDOW CLOSURE SENSORS
12b
MICROWAVE AREA SENSORS
12c
BREAK-BEAM SENSORS
12d
PASSIVE I/R AREA SENSORS
12e
PRESSURE MATS
12f
12g
VIDEO CAMERA
$12g_1$
VIDEO MOTION DETECTOR
$12g_2$
12
MOBILE ROBOT #1
18
MOBILE ROBOT #n
18
$20b_1$
$20b_2$
$20b_1$
$20b_2$
AUX INPUT
VIDEO RECEIVER
20c
VIDEO MUX
24
VCR
26
ALARM INTERFACE UNIT
16
VIDEO MUX CONTROL
VIDEO SIGNAL
VCR CONTROL
INTERFACE BUS
VIDEO
ALARM SYSTEM
22
RF DATA LINK
20a
HOST CPU
14
VIDEO MONITOR
15
VIDEO MONITOR
28

FIG. 2

FIG. 3A

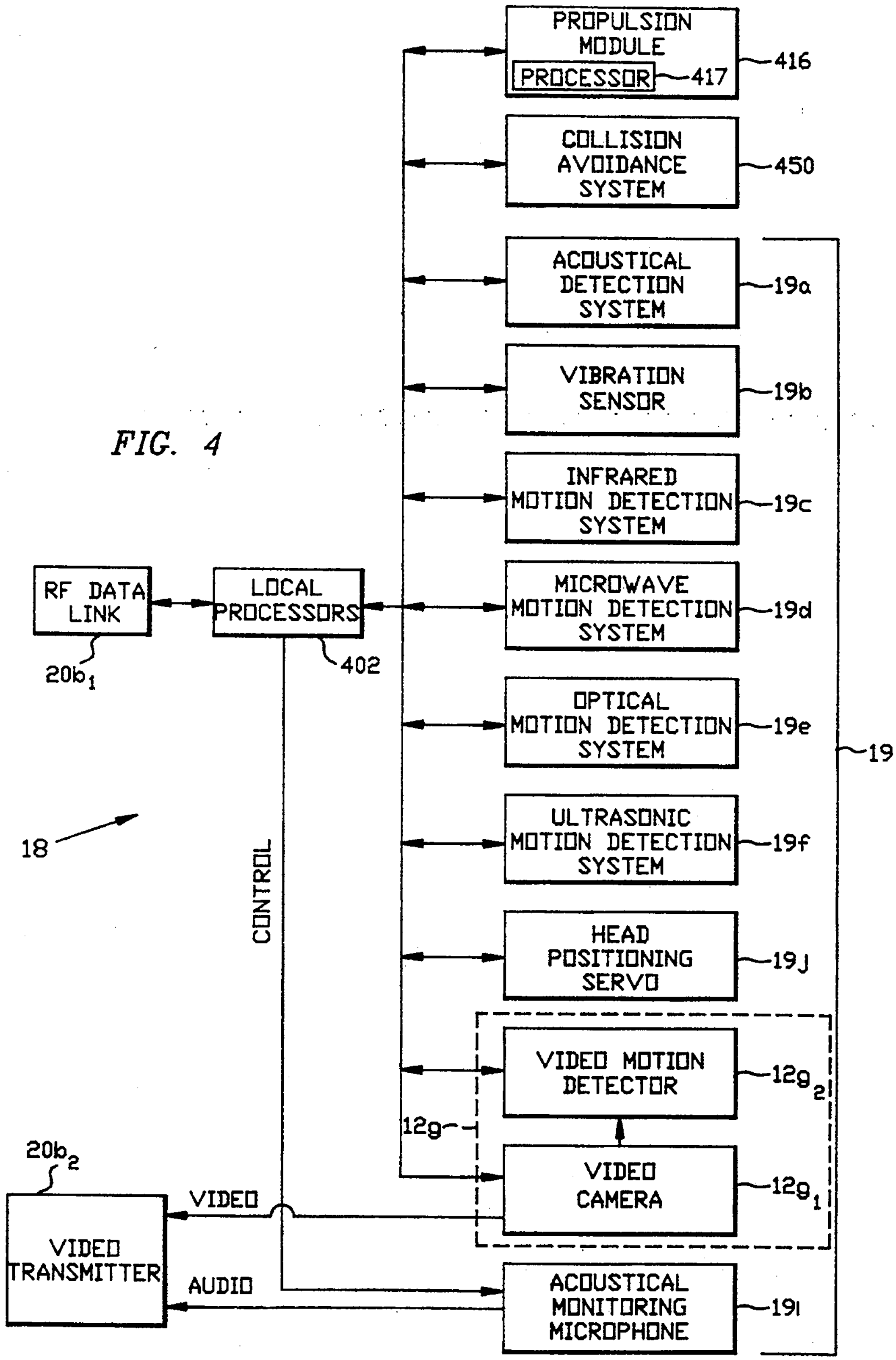

OUTPUTS
OUTPUTS
OUTPUTS
LS244
LS244
LS244
IC7
IC8
IC9
LS259
LS259
LS259
IC3
IC4
IC5
+5V
+5V
+5V
LS139
IC2
LS04
IC1



OUTPUTS
LS244
IC10
LS259
IC6
+5V
4067
IC12
IC11
Input 1
Input 2
Input 3
Input 4
Input 5
Input 6
Input 7
Input 8
Input 9
Input 10
Input 11
Input 12
Input 13
Input 14
Input 15
Input 16
Input 17
Input 18
Input 19
Input 20
Input 21
Input 22
Input 23
Input 24
Input 25
Input 26
Input 27
Input 28
Input 29
Input 30
Input 31
Input 32
OUTA0
OUTA1
OUTA2
SELA
SELB
DATA OUT
DATA IN
25-DB
SERIAL PARALLEL ADAPTER
-STROBE
DB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
-ACK
BUSY
PE
SLCT
-AUTOF
-ERROR
-INIT
-SLCTIN
GND(18~25)
TO HOST COMPUTER PC PRINTER PORT
FIG. 3A
FIG. 3B

FIG. 3B

FIG. 4


PROPULSION MODULE
PROCESSOR
417
416
COLLISION AVOIDANCE SYSTEM
450
ACOUSTICAL DETECTION SYSTEM
19a
VIBRATION SENSOR
19b
INFRARED MOTION DETECTION SYSTEM
19c
RF DATA LINK
LOCAL PROCESSORS
MICROWAVE MOTION DETECTION SYSTEM
19d
20b1
402
OPTICAL MOTION DETECTION SYSTEM
19e
19
18
ULTRASONIC MOTION DETECTION SYSTEM
19f
CONTROL
HEAD POSITIONING SERVO
19j
VIDEO MOTION DETECTOR
12g2
12g
20b2
VIDEO CAMERA
12g1
VIDEO
VIDEO TRANSMITTER
AUDIO
ACOUSTICAL MONITORING MICROPHONE
19i

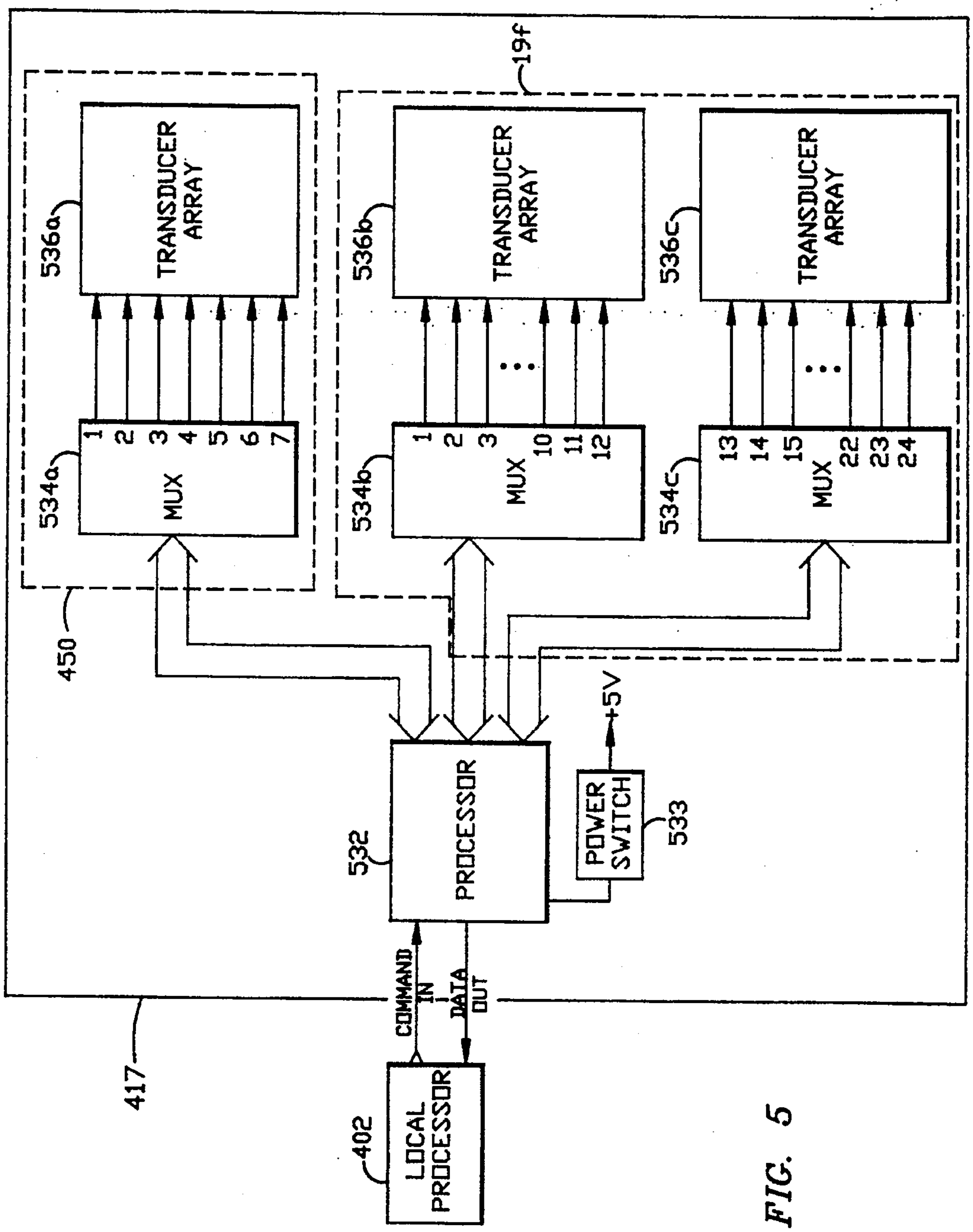

TRANSDUCER ARRAY
536a
1 2 3 4 5 6 7
MUX
534a
450
19f
TRANSDUCER ARRAY
536b
1 2 3 10 11 12
MUX
534b
TRANSDUCER ARRAY
536c
13 14 15 22 23 24
MUX
534c
+5V
PROCESSOR
532
POWER SWITCH
533
COMMAND IN
DATA OUT
417
LOCAL PROCESSOR
402

FIG. 5

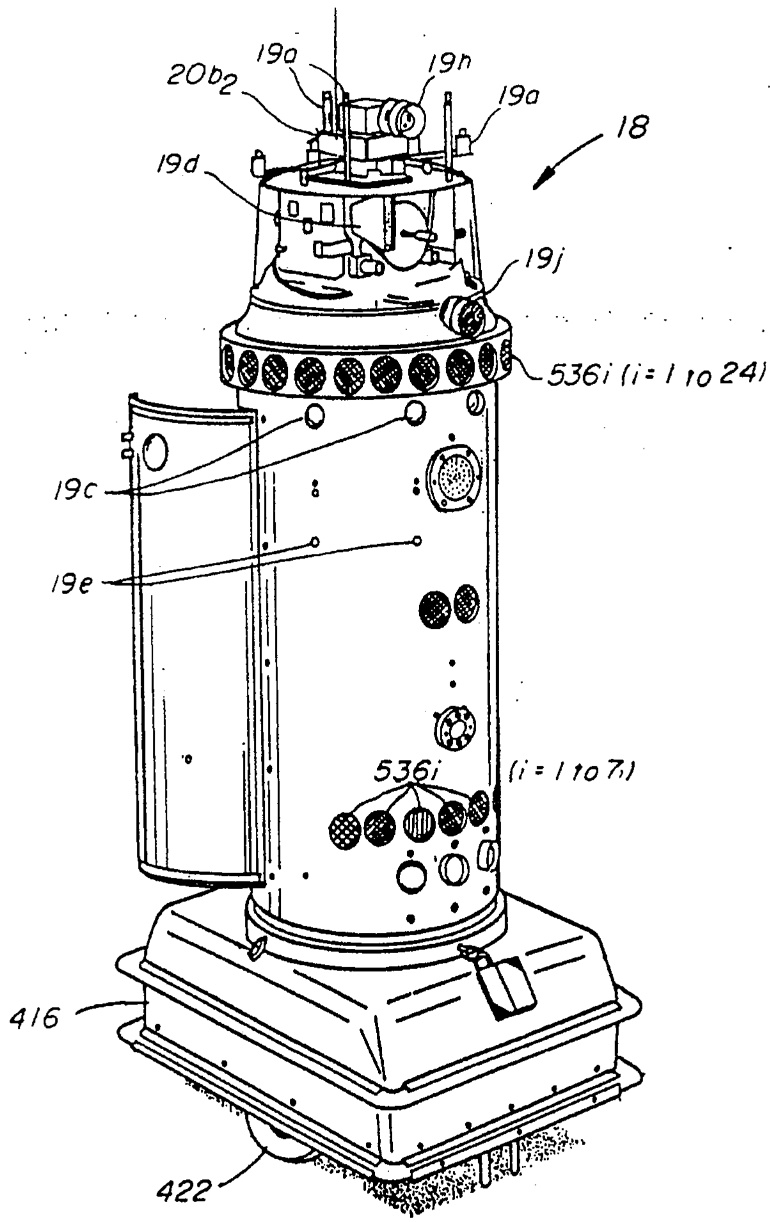

19a
20b2
19h
19a
18
19d
19j
536i (i = 1 to 24)
19c
19e
536i
(i = 1 to 7)
416
422

FIG. 6

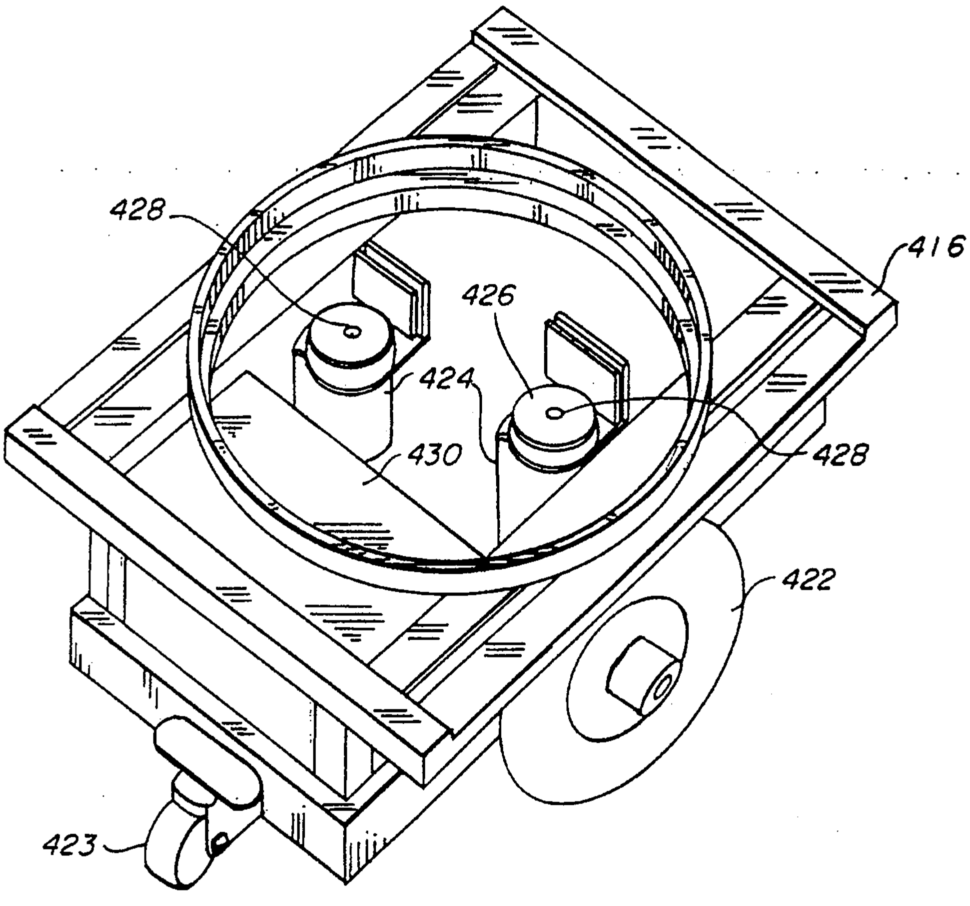


FIG.7

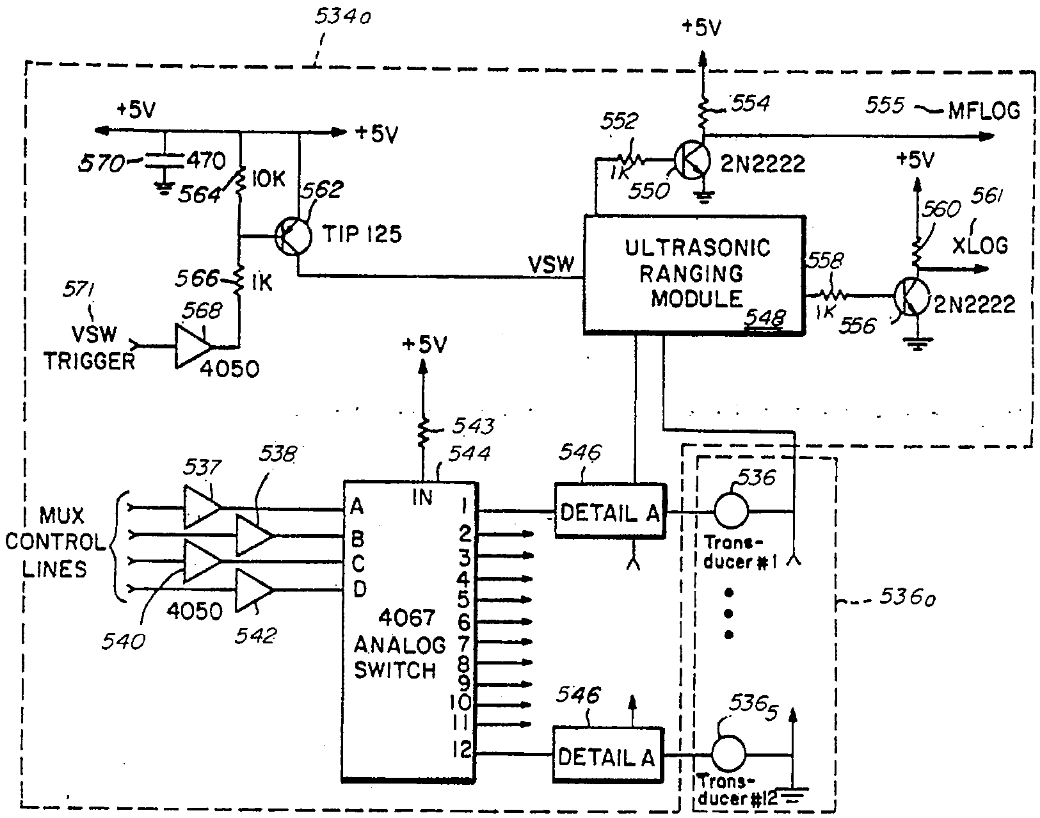

534o
+5V
+5V
+5V
555 MFLOG
554
552
570
470
10K
564
562
TIP 125
1K
550
2N2222
+5V
560
561
XLOG
VSW
ULTRASONIC
RANGING
MODULE
548
558
1K
556
2N2222
571
VSW
TRIGGER
566
1K
568
4050
+5V
543
544
537
538
546
536
MUX
CONTROL
LINES
A
B
C
D
IN
DETAIL A
Trans-
ducer #1
536o
4067
ANALOG
SWITCH
4050
540
542
546
DETAIL A
Trans-
ducer #12

FIG. 8

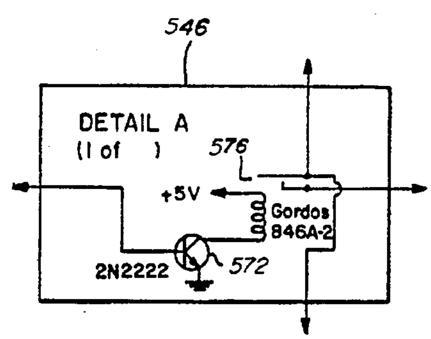

546
DETAIL A
(1 of)
576
+5V
Gordos
846A-2
2N2222
572

FIG. 9

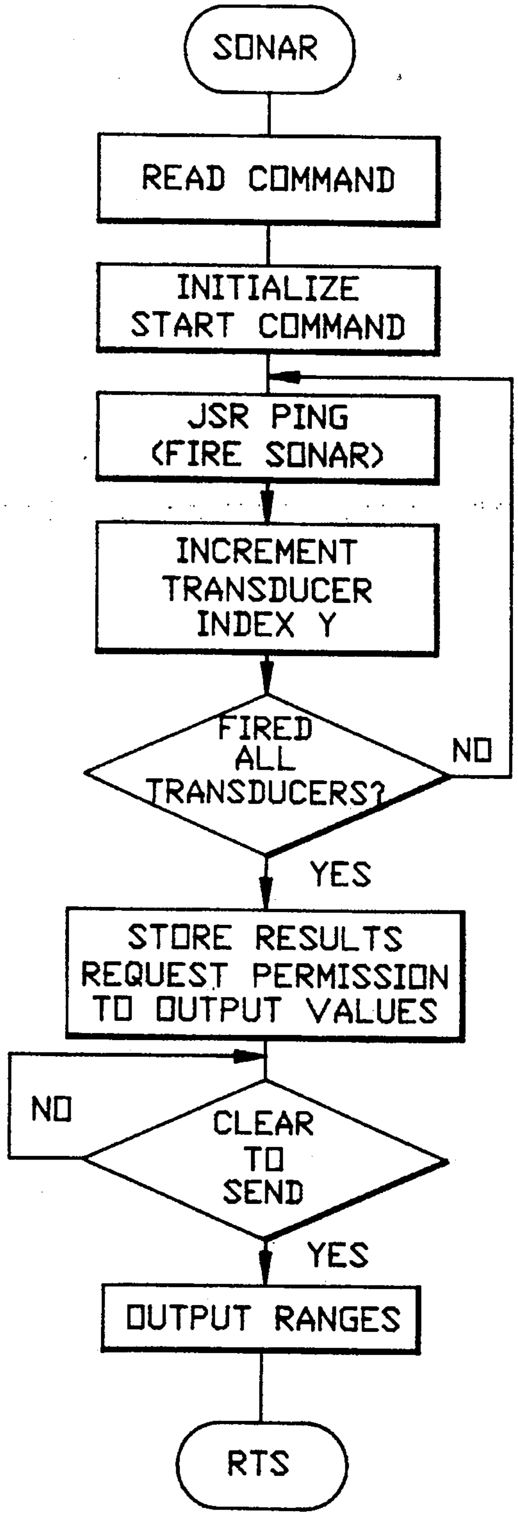

SONAR
READ COMMAND
INITIALIZE START COMMAND
JSR PING (FIRE SONAR)
INCREMENT TRANSDUCER INDEX Y
FIRED ALL TRANSDUCERS?
NO
YES
STORE RESULTS REQUEST PERMISSION TO OUTPUT VALUES
NO
CLEAR TO SEND
YES
OUTPUT RANGES
RTS

FIG. 10

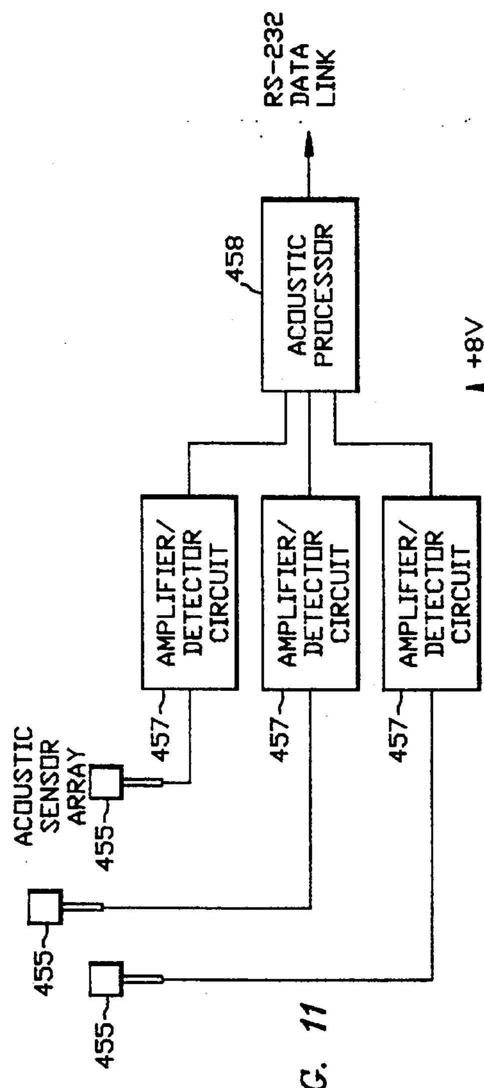

ACOUSTIC SENSOR ARRAY
455
457
AMPLIFIER/ DETECTOR CIRCUIT
458
ACOUSTIC PROCESSOR
RS-232 DATA LINK

FIG. 11

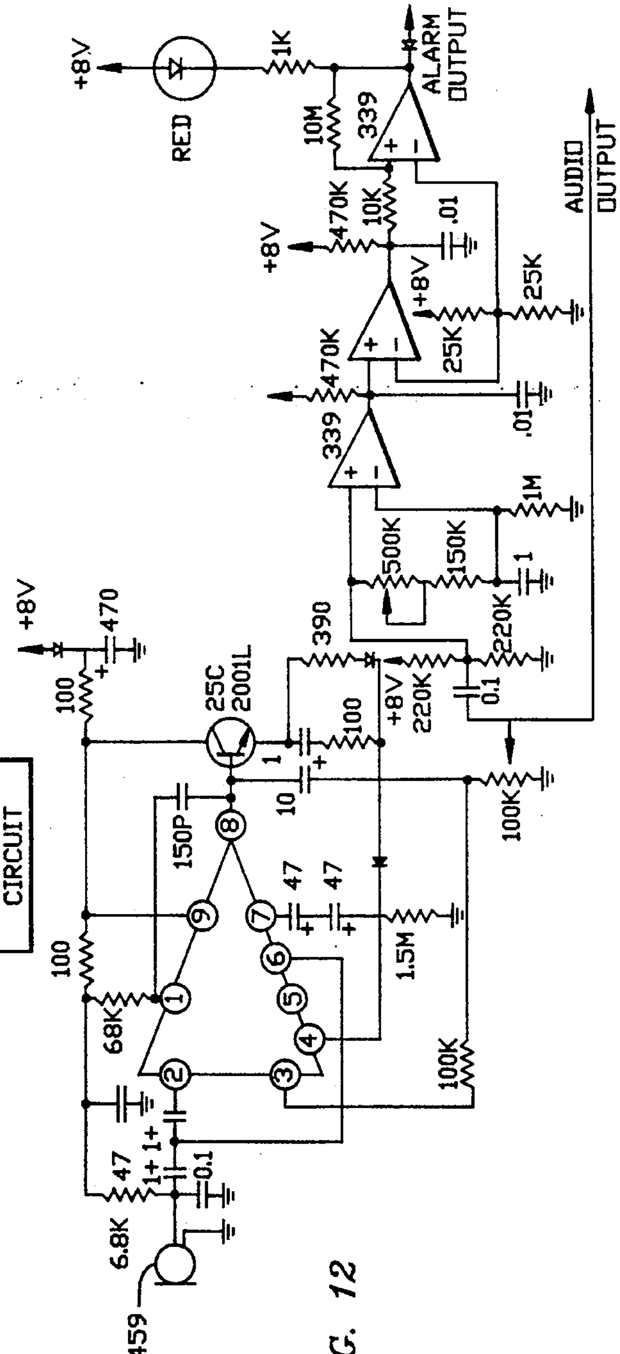

459
6.8K
47
1+
0.1
100
68K
150P
25C 2001L
+8V
470
10
1
390
1.5M
100K
220K
500K
150K
1M
339
470K
.01
25K
10K
10M
1K
RED
ALARM OUTPUT
AUDIO OUTPUT

FIG. 12

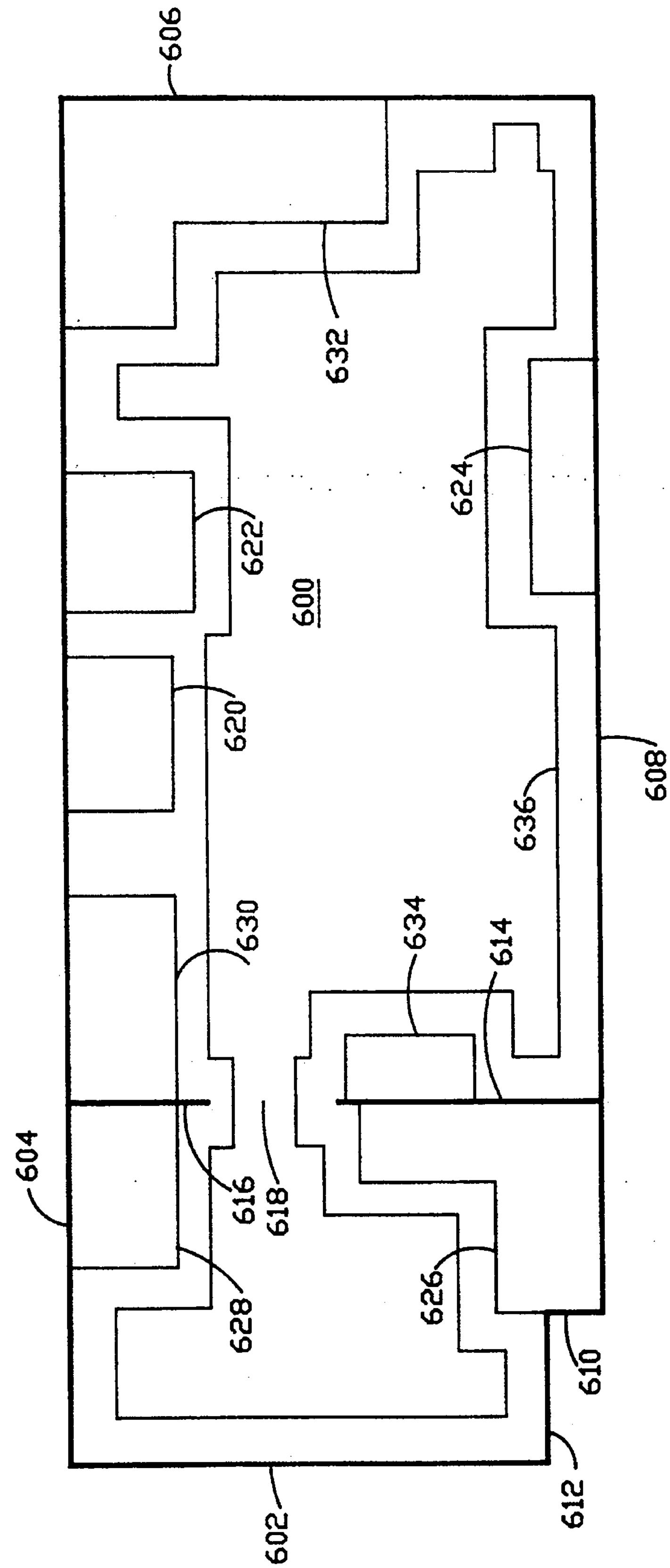

606
632
624
622
600
620
608
636
634
614
630
604
616
618
628
626
610
602
612

FIG. 13

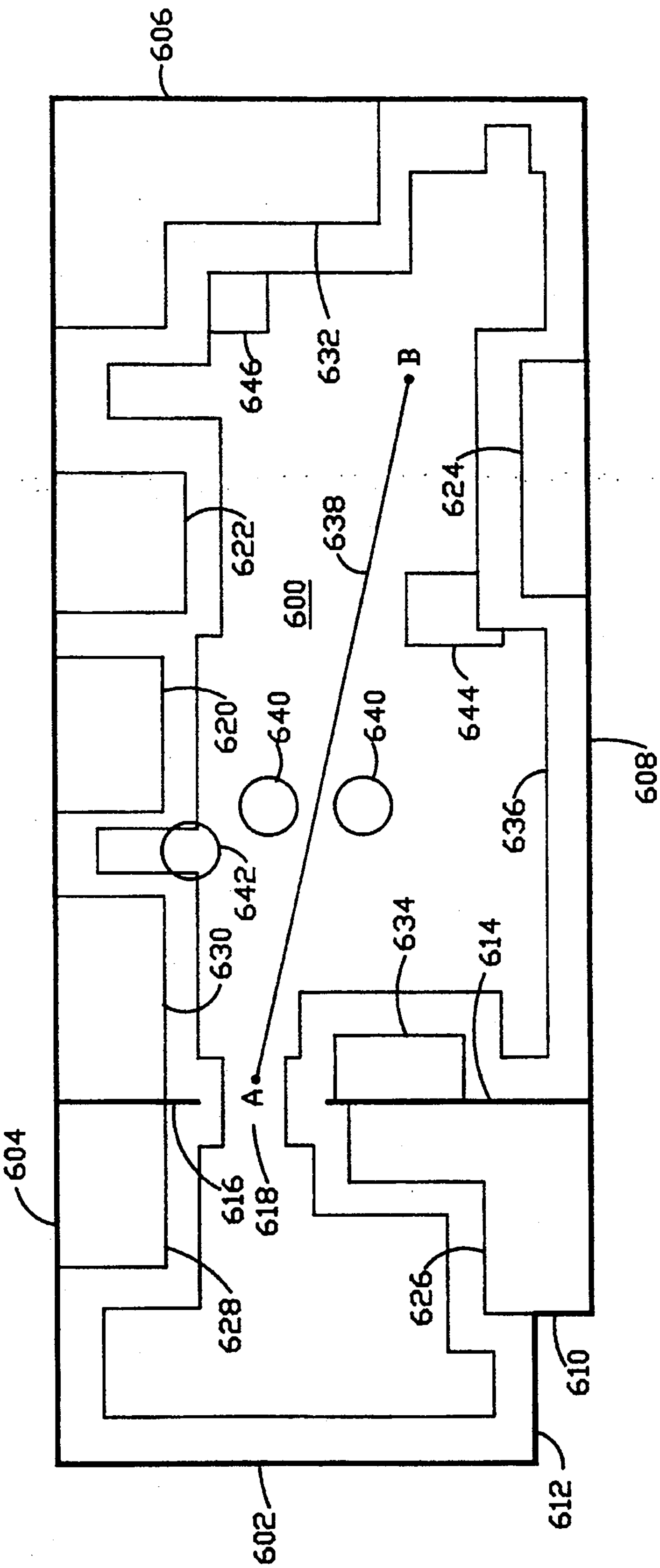

606
632
646
B
624
622
638
600
620
640
640
644
608
636
642
630
634
614
A
604
616
618
628
626
610
612
602

FIG. 14

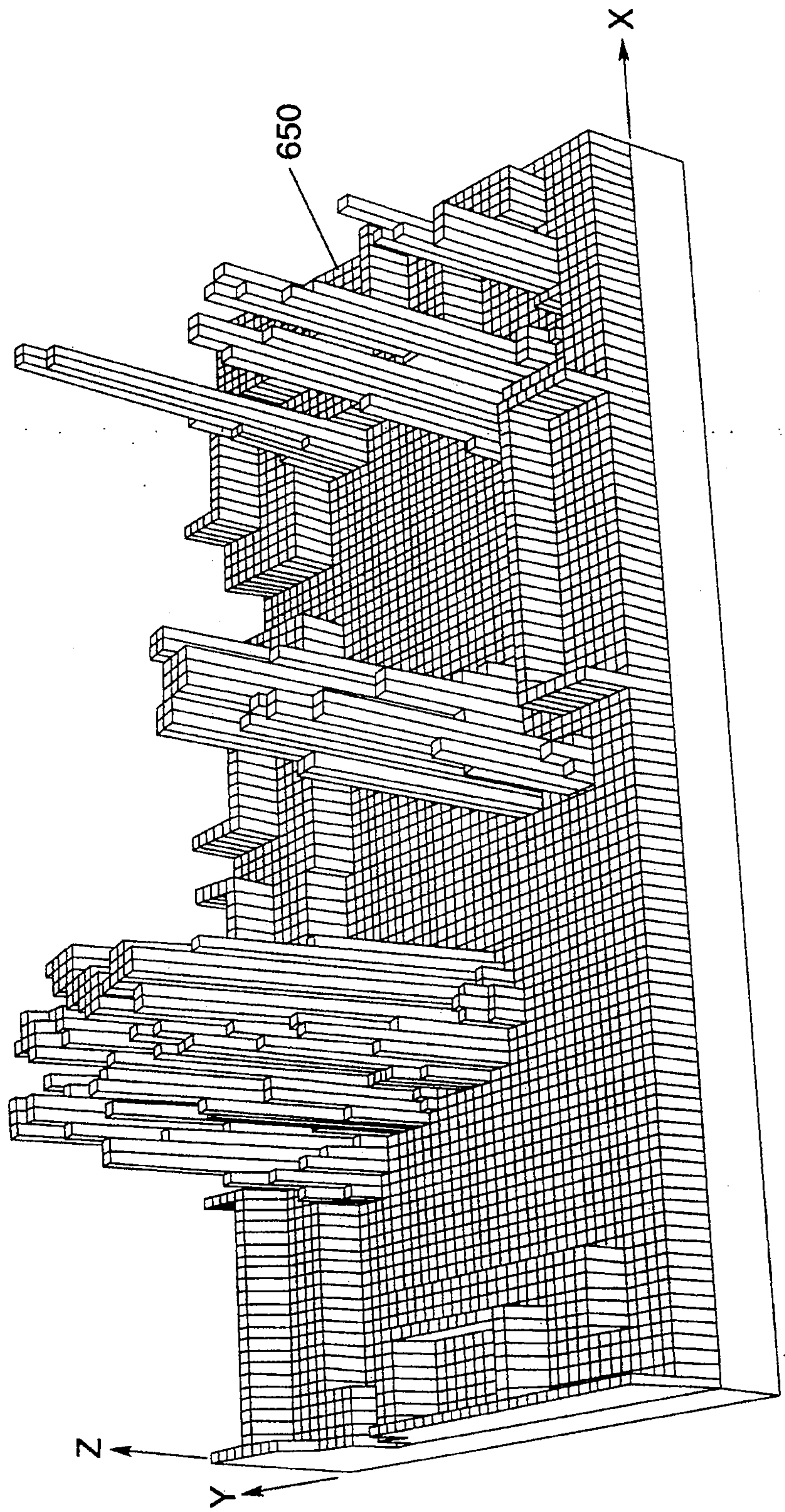


FIG. 15

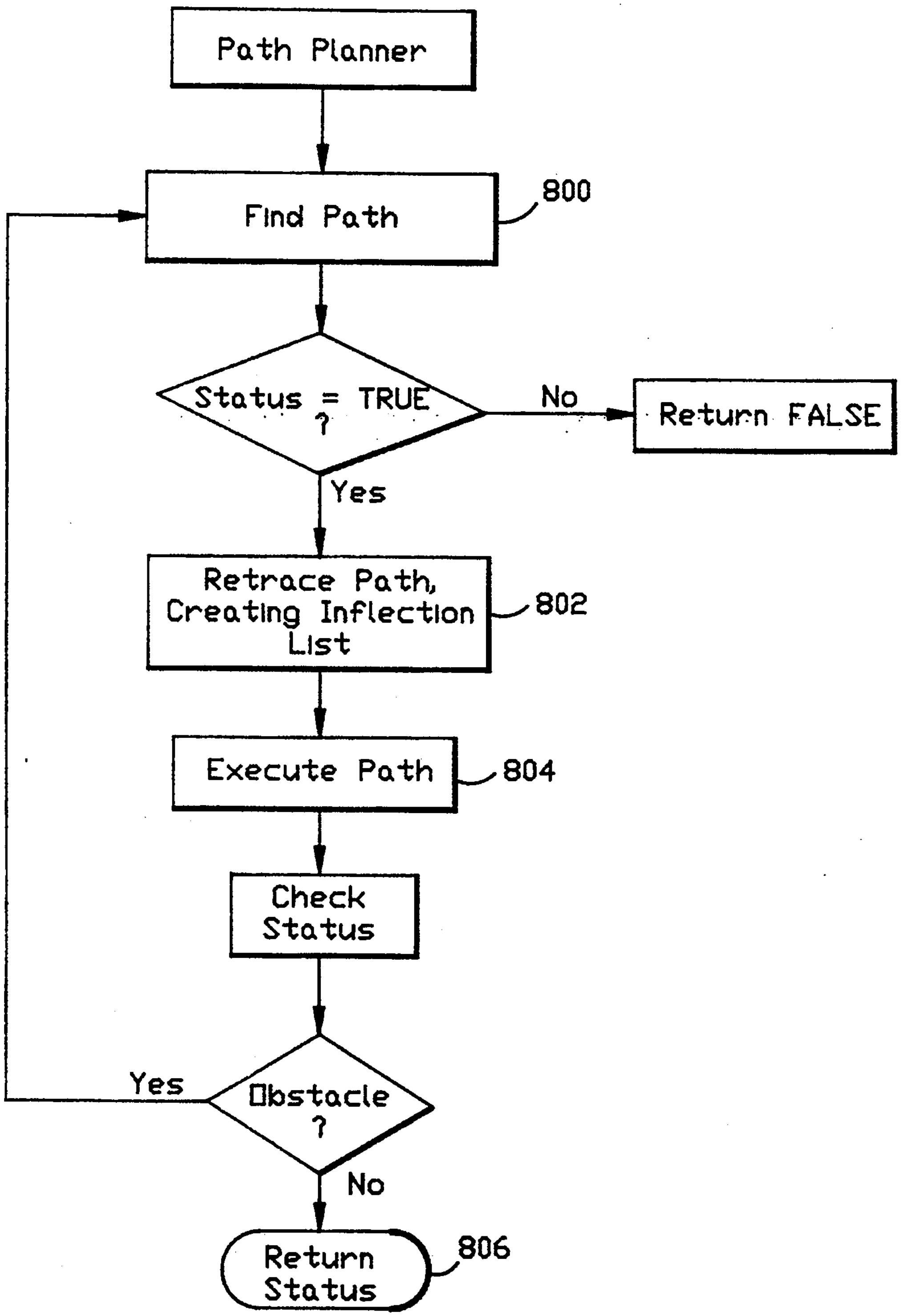

Path Planner
Find Path
800
Status = TRUE ?
No
Return FALSE
Yes
Retrace Path, Creating Inflection List
802
Execute Path
804
Check Status
Yes
Obstacle ?
No
Return Status
806

FIG. 16

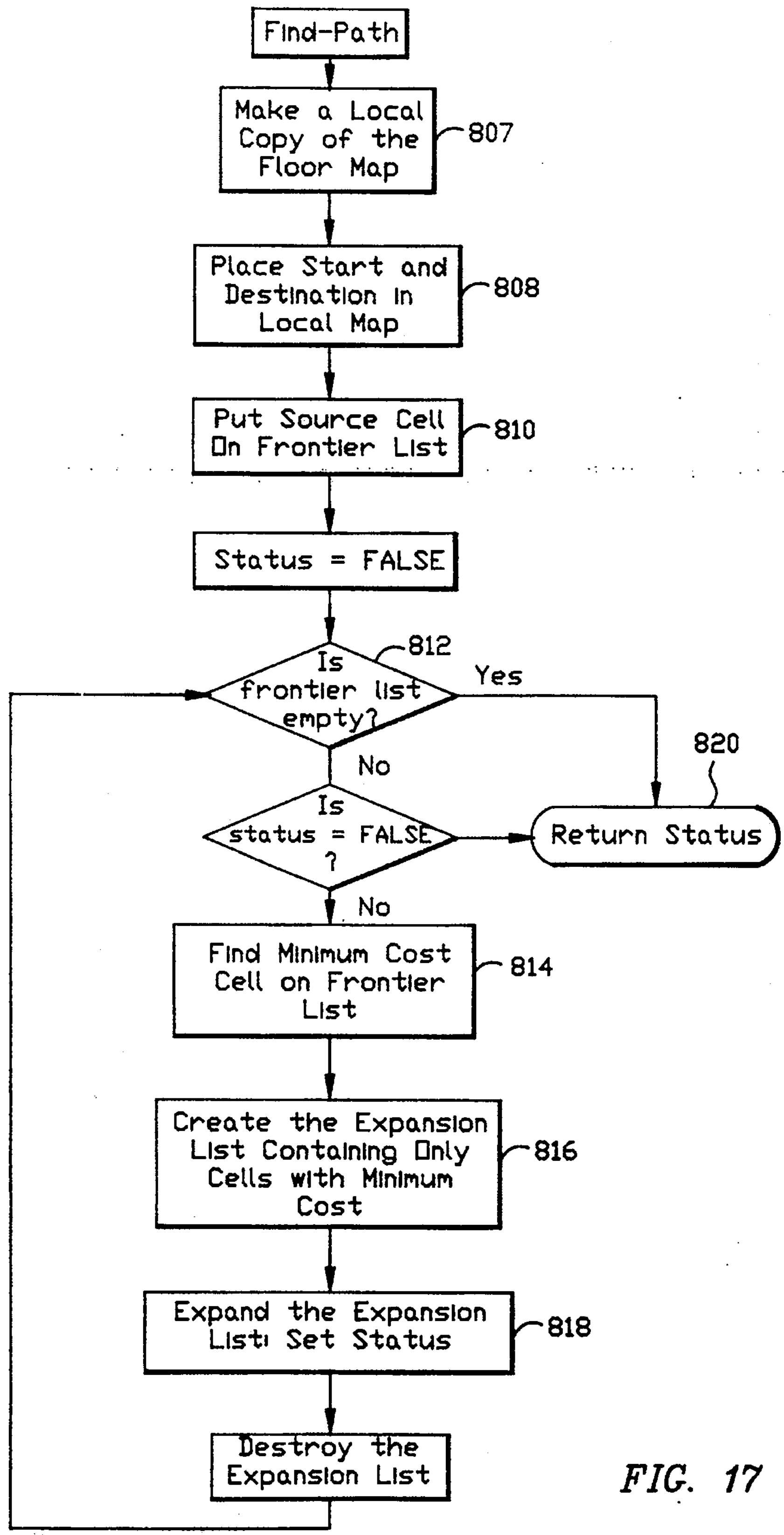
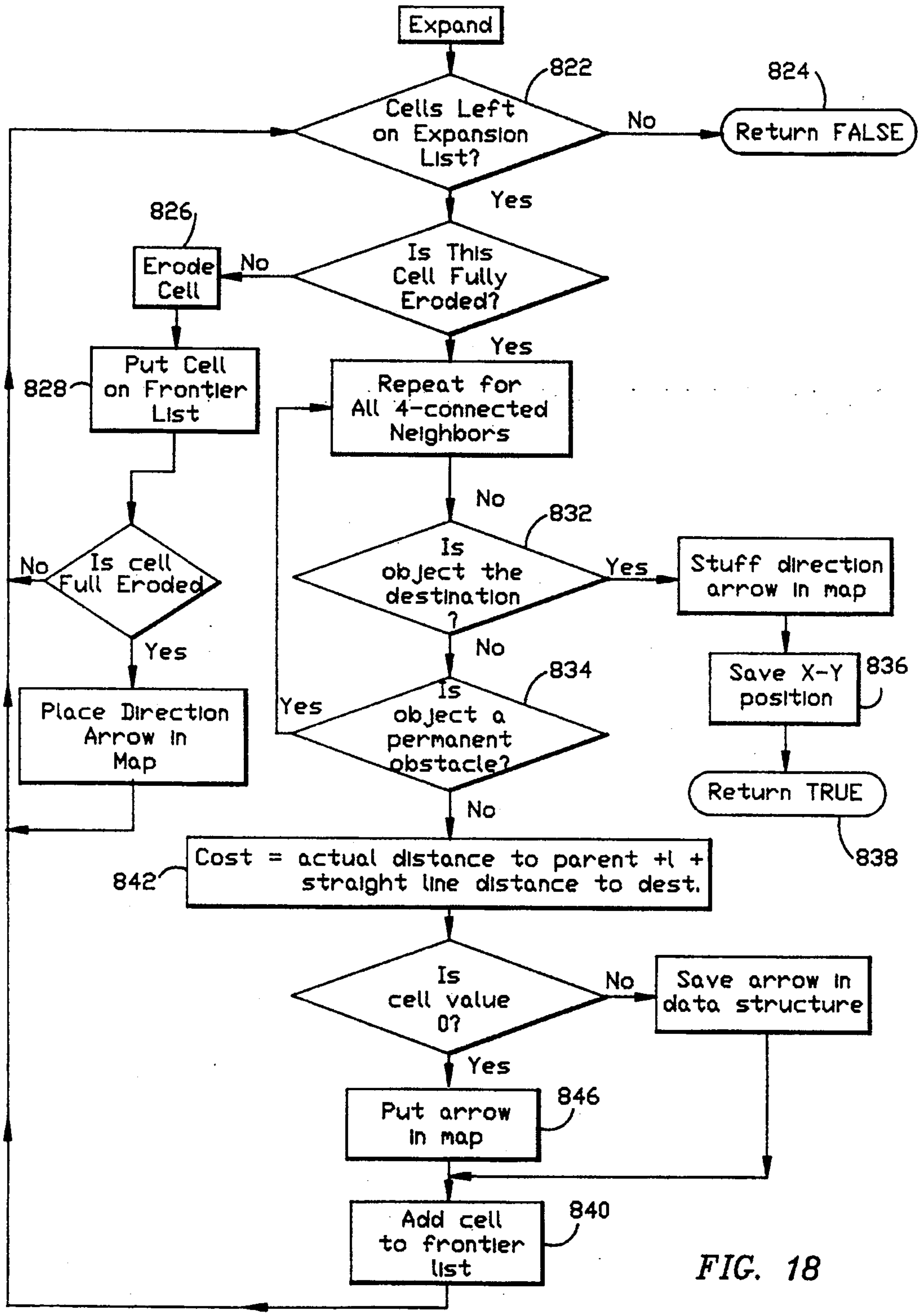

Find-Path
Make a Local Copy of the Floor Map
807
Place Start and Destination in Local Map
808
Put Source Cell On Frontier List
810
Status = FALSE
812
Is frontier list empty?
Yes
No
820
Is status = FALSE ?
Return Status
No
Find Minimum Cost Cell on Frontier List
814
Create the Expansion List Containing Only Cells with Minimum Cost
816
Expand the Expansion List; Set Status
818
Destroy the Expansion List

FIG. 17



Expand
822
Cells Left on Expansion List?
No
824
Return FALSE
Yes
826
Erode Cell
No
Is This Cell Fully Eroded?
Yes
828
Put Cell on Frontier List
Repeat for All 4-connected Neighbors
No
832
No
Is cell Full Eroded
Yes
Is object the destination ?
Yes
Stuff direction arrow in map
No
834
836
Save X-Y position
Place Direction Arrow in Map
Yes
Is object a permanent obstacle?
Return TRUE
No
838
842
Cost = actual distance to parent +1 + straight line distance to dest.
Is cell value 0?
No
Save arrow in data structure
Yes
846
Put arrow in map
840
Add cell to frontier list

FIG. 18

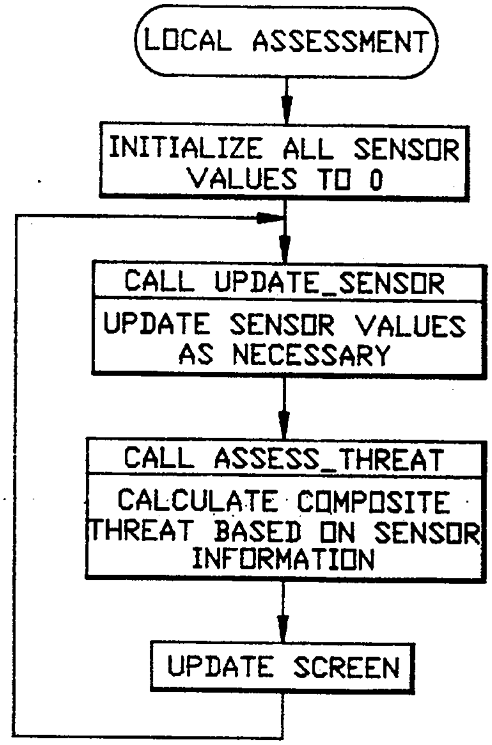

LOCAL ASSESSMENT
INITIALIZE ALL SENSOR VALUES TO 0
CALL UPDATE_SENSOR
UPDATE SENSOR VALUES AS NECESSARY
CALL ASSESS_THREAT
CALCULATE COMPOSITE THREAT BASED ON SENSOR INFORMATION
UPDATE SCREEN

FIG. 23

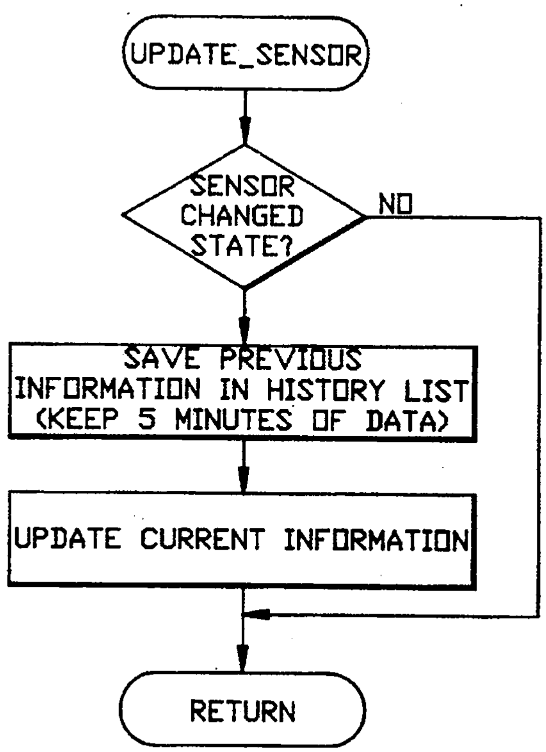

UPDATE_SENSOR
SENSOR CHANGED STATE?
NO
SAVE PREVIOUS INFORMATION IN HISTORY LIST (KEEP 5 MINUTES OF DATA)
UPDATE CURRENT INFORMATION
RETURN

FIG. 24

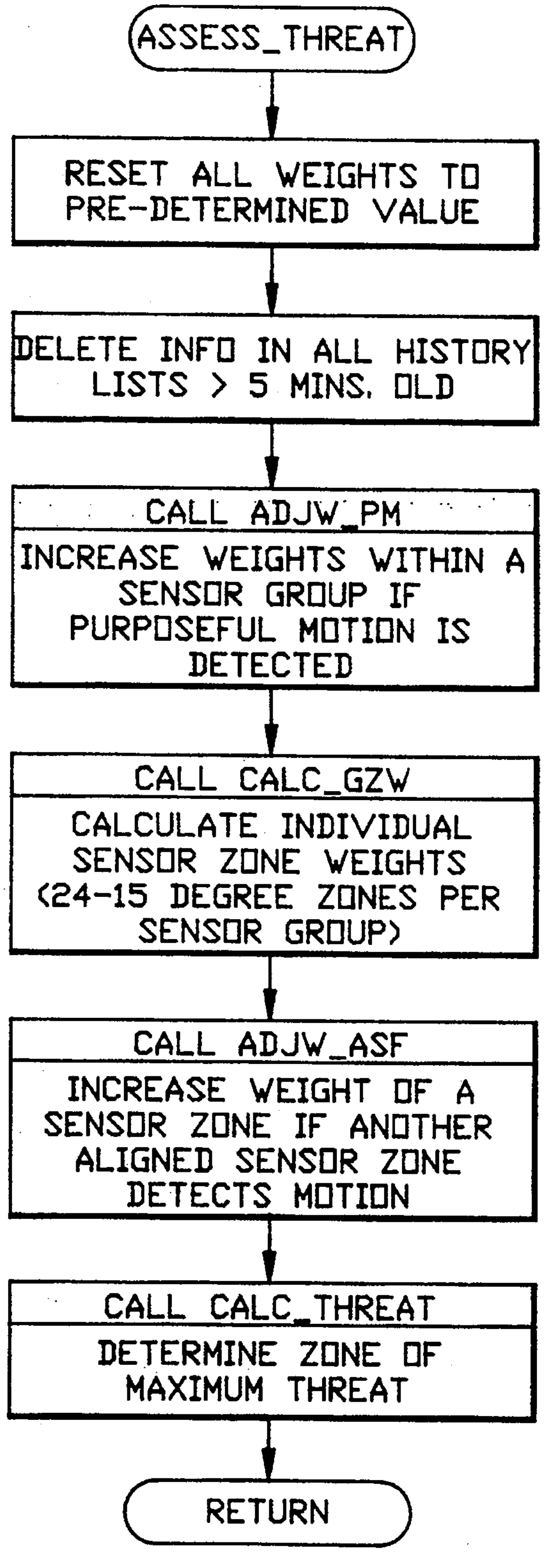

ASSESS_THREAT
RESET ALL WEIGHTS TO PRE-DETERMINED VALUE
DELETE INFO IN ALL HISTORY LISTS > 5 MINS. OLD
CALL ADJW_PM
INCREASE WEIGHTS WITHIN A SENSOR GROUP IF PURPOSEFUL MOTION IS DETECTED
CALL CALC_GZW
CALCULATE INDIVIDUAL SENSOR ZONE WEIGHTS (24-15 DEGREE ZONES PER SENSOR GROUP)
CALL ADJW_ASF
INCREASE WEIGHT OF A SENSOR ZONE IF ANOTHER ALIGNED SENSOR ZONE DETECTS MOTION
CALL CALC_THREAT
DETERMINE ZONE OF MAXIMUM THREAT
RETURN

FIG. 25

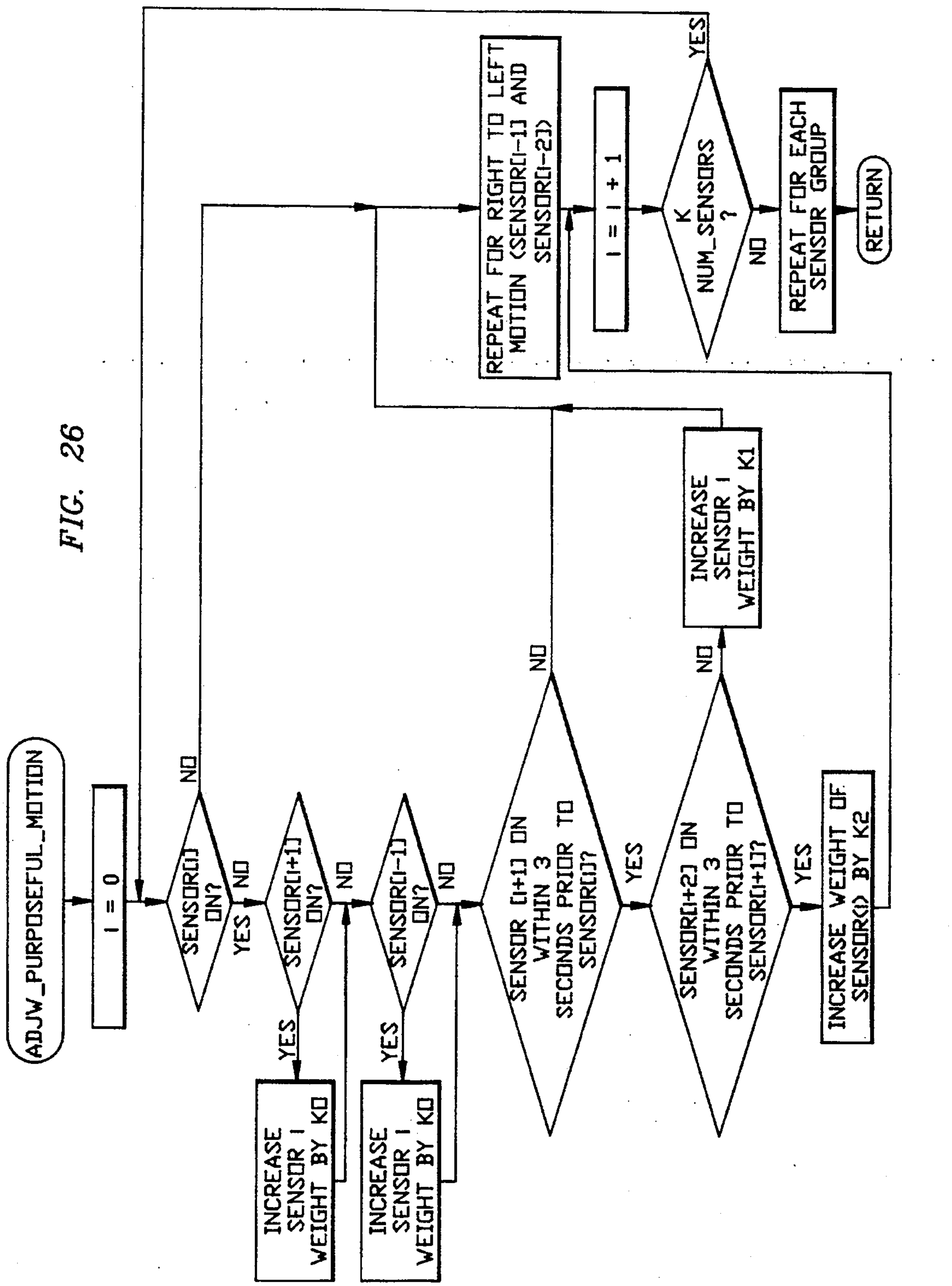

ADJW_PURPOSEFUL_MOTION
I = 0
SENSOR[I] ON?
NO
YES
SENSOR[I+1] ON?
YES
NO
INCREASE SENSOR I WEIGHT BY K0
SENSOR[I-1] ON?
YES
NO
INCREASE SENSOR I WEIGHT BY K0
SENSOR [I+1] ON WITHIN 3 SECONDS PRIOR TO SENSOR[I]?
NO
YES
SENSOR[I+2] ON WITHIN 3 SECONDS PRIOR TO SENSOR[I+1]?
NO
YES
INCREASE SENSOR I WEIGHT BY K1
INCREASE WEIGHT OF SENSOR(I) BY K2
REPEAT FOR RIGHT TO LEFT MOTION (SENSOR[I-1] AND SENSOR[I-2])
I = I + 1
K NUM_SENSORS ?
YES
NO
REPEAT FOR EACH SENSOR GROUP
RETURN

FIG. 26

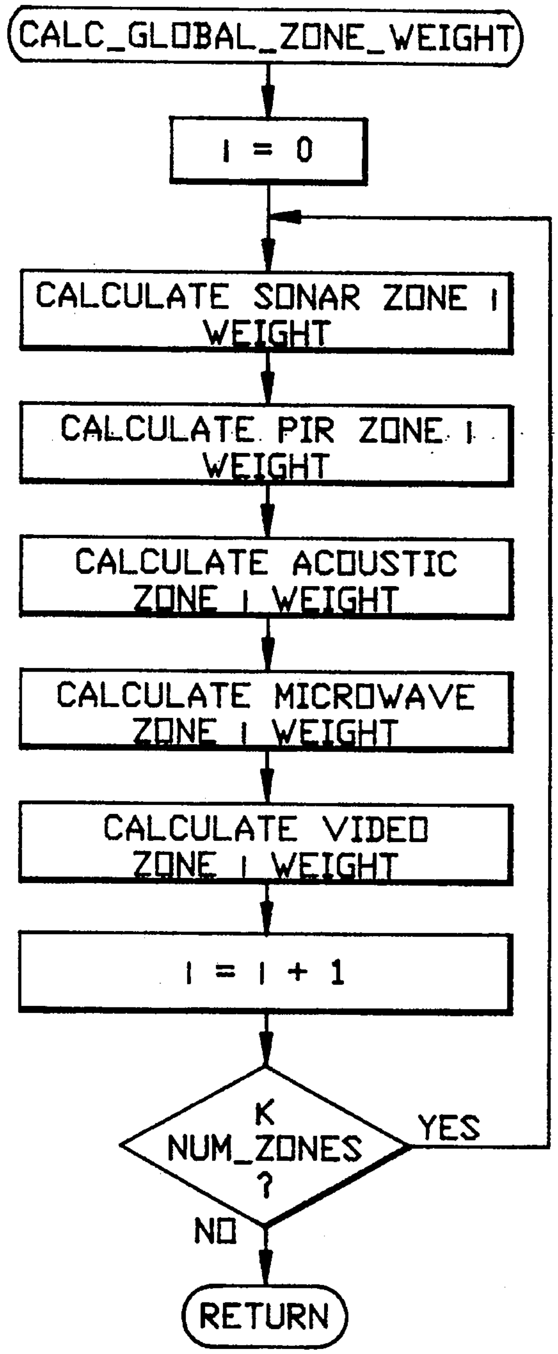
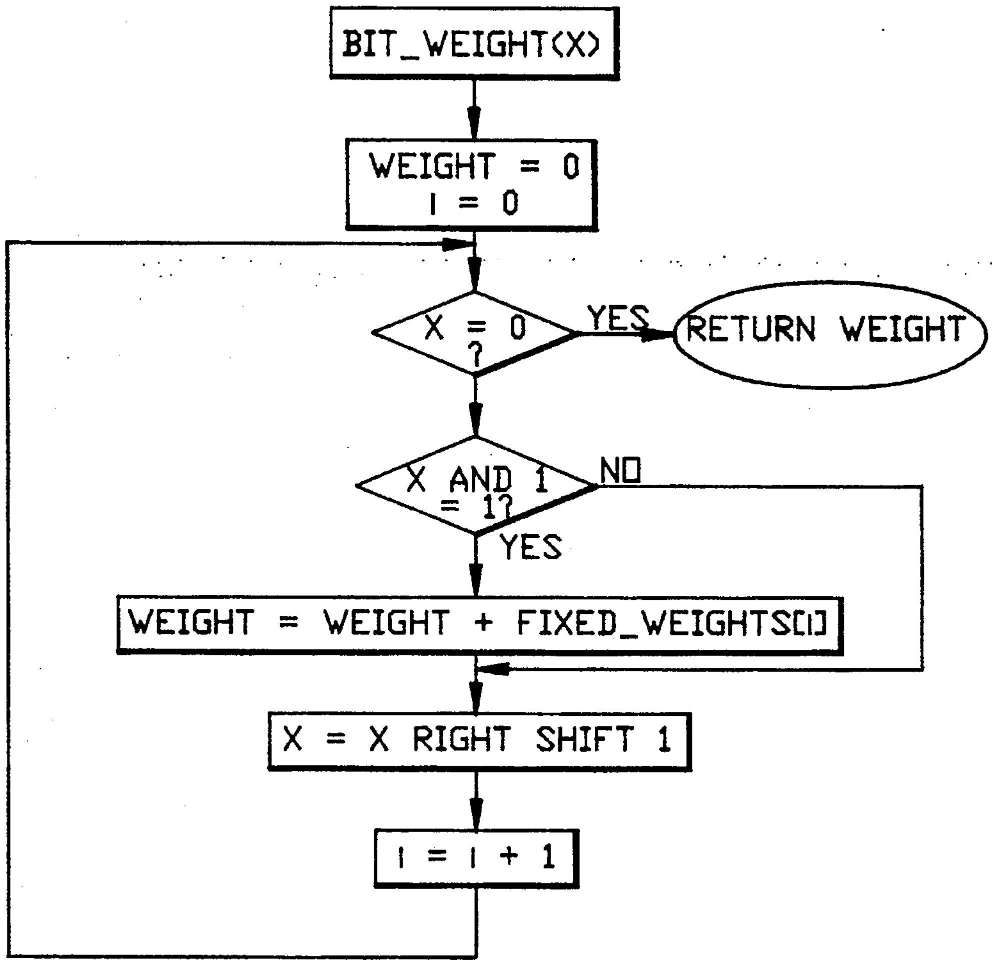

CALC_GLOBAL_ZONE_WEIGHT
I = 0
CALCULATE SONAR ZONE I WEIGHT
CALCULATE PIR ZONE I WEIGHT
CALCULATE ACOUSTIC ZONE I WEIGHT
CALCULATE MICROWAVE ZONE I WEIGHT
CALCULATE VIDEO ZONE I WEIGHT
I = I + 1
K NUM_ZONES ?
YES
NO
RETURN

FIG. 27



BIT_WEIGHT(X)
WEIGHT = 0
I = 0
X = 0
?
YES
RETURN WEIGHT
X AND 1
= 1?
NO
YES
WEIGHT = WEIGHT + FIXED_WEIGHTS[I]
X = X RIGHT SHIFT 1
I = I + 1

FIG. 36

METHOD AND SYSTEM FOR FUSING DATA FROM FIXED AND MOBILE SECURITY SENSORS

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

The present invention relates to the general field of intrusion detection systems for secure environments, and more particularly to a system that integrates the outputs of both fixed and mobile intrusion detection sensors in order to provide intelligent assessments of the level of security of the environment.

Most security systems utilize fixed sensors such as motion detectors and/or video cameras positioned at specific locations throughout the environment to be secured. Such environments include buildings, military bases, warehouses, storage yards, factories, and even homes. A very great disadvantage with video camera surveillance is that it requires an alert human to monitor a bank of video displays over long periods of time. If the human becomes distracted or fatigued, he may not notice an intrusion. Another problem with such security systems is that in order to be sensitive enough to detect a potential intrusion, they are subject to nuisance trips. This causes erosion in confidence in these systems. Furthermore, such systems do not provide sufficient resolution to be able to identify the specific nature of an intrusion or its precise location. Further, fixed positioned intrusion detectors are not capable of tracking an intruder's position with any real accuracy.

If the environment to be secured is very large, it becomes economically difficult to provide adequate sensor coverage throughout the entire environment with fixed sensors. Furthermore, the fact that the sensors are positioned at fixed locations makes them vulnerable to being neutralized by a determined intruder.

There exists a tradeoff point wherein it becomes more cost effective to outfit a platform with numerous sensors, and let it travel from zone to zone, as opposed to installing, wiring, and protecting the fixed installation of these same sensors so that all areas within a space are effectively covered. This is obviously a function of the conditions to be monitored and the unit cost of the appropriate sensors, as well as the number of areas and geometric configuration of the space to be protected. Some provision must be made to preclude site vulnerability when the robot is not on station, or perhaps even down for maintenance. For these reasons, a combination of both fixed and mobile sensors is likely to evolve as the appropriate solution in most cases, but obvious problems arise with the operation of a mobile platform in an area protected by permanently installed motion detectors, in that the motion of the robots will set off the fixed alarms.

Therefore, a need exists for a security system which allows one or more mobile robots to operate in an area protected by fixed intrusion detectors. Furthermore, a need exists for an intrusion detection system that is capable of detecting the presence of a potential intrusion, then scrutinizing the potential intrusion with greater resolution to ascertain the nature of the intrusion, then determining the probability of an actual intrusion to minimize nuisance trips, and then providing an intruder alarm if the threat of intrusion exceeds a specific level of confidence that an actual intrusion has occurred.

SUMMARY OF THE INVENTION

The present invention provides a system for detecting intrusion into a secured environment using both fixed and mobile intrusion detectors. The invention employs an optimal mix of fixed sensors, positioned at specific locations throughout the environment, and sensors mounted on one or more mobile robots that patrol the secured environment. The outputs of the fixed and mobile sensors are fused by a computer-based system that emulates the assessment functions of its human counterpart. The system knows at all times where the robots are located, the zones of coverage for the mobile sensor suites, and the resultant effect of the robot's presence or motion on fixed intrusion detection sensors viewing that same area.

The concept of mobility provides an unpredictable pattern with respect to precise sensor location and orientation, making the job of casing a scenario for the purpose of identifying blind spots rather difficult indeed. The random patrols and the uncertainty in the mind of the intruder as to what the robot's response might be upon detection adds a psychological advantage to the deterrent function of the security system. An important advantage of the present invention is that if the fixed sensors detect a potential intrusion, the computer directs a mobile robot to the vicinity to investigate the situation further.

The sensor suite onboard the mobile robot contains multiple, high resolution sensors of different types that are automatically oriented towards the potential intruder. Data obtained from the mobile sensors is used to determine the probability of an actual intrusion so that nuisance trips are minimized. If an actual intrusion has occurred, the mobile robots are directed by the computer to follow the intruder and report the intruder's position. All this occurs in realtime. If the confidence level of an intrusion exceeds a threshold, an intruder alert is provided. Thus, this invention obviates the demanding and tedious vigilance of a human required by conventional security systems.

A multiplicity of fixed intrusion detection sensors are each deployed at specific, fixed locations within the environment. The mobile sensors are mounted on robots which selectively patrol throughout the environment and may be rapidly deployed to any region in the environment where a fixed intrusion detector detects a possible intrusion. A computer receives the outputs of the fixed and mobile sensors and is communicatively coupled to the mobile robots. The computer directs the mobile robots to travel through the environment along paths calculated by the computer, calculates a sum of weighing factors associated with the output of each sensor, and fuses the sensor outputs so that the sum is uninfluenced by the traveling of the mobile robots. The sum is compared to a reference whereby an output is provided when the sum exceeds the reference. An alarm system operably coupled to the computer provides an intrusion alert when the output received exceeds the reference. X-Y positional data and the activated sensor corresponding to an identified intrusion is presented on a video display.

Data fusion is accomplished such that the robot's motion does not trigger a 'fixed' sensor alarm, and data from both 'fixed' and 'mobile' sensors can be collectively assessed in calculating a composite threat score

from individual sensor weightings, so as to achieve a high probability of detection with a corresponding low nuisance alarm rate.

The present invention also provides a method for operating a security system having fixed and mobile intrusion detectors in a secured environment, where the mobile intrusion detectors are mounted on one or more mobile robots, and each the fixed and mobile intrusion detectors has a coverage zone. This method includes the steps of: (1) initializing a mathematical model of a fixed intrusion detector map comprised of nodes each having an initial value; (2) determining the position of the mobile robot; (3) initializing a mathematical model of a mobile intrusion detector coverage map comprised of nodes having an initial value; (4) reading the outputs of the fixed and mobile intrusion detectors; (5) determining which the fixed intrusion detector coverage zones include the position of the mobile robot; (6) inhibiting data corresponding to the outputs of any of the fixed intrusion detectors that have the coverage zones that include the mobile robot; (7) assigning a weight to data corresponding to each mobile intrusion detector zone associated with a mobile intrusion detector detecting a potential intrusion by: (8) examining a sequence trigger history of the mobile intrusion detectors in order to ascertain the presence of purposeful motion by the potential intrusion in any of the mobile intrusion detector zones associated with a mobile intrusion detector detecting the potential intrusion; (9) increasing the weights calculated in step 7 for each mobile intrusion detector threat score by a predetermined amount for each of the mobile intrusion detector zones in which the purposeful motion is detected; (10) determining a mobile intrusion detector threat score by summing the weights determined in steps 7, 8 and 9; (11) correlating the outputs of the fixed and mobile intrusion detectors by identifying a maximum weighted sum corresponding to the outputs of the fixed intrusion detectors detecting the potential intrusion, and having an associated fixed intrusion detector zone that intersects a mobile intrusion detector zone in which the potential intrusion has been identified by; (12) rotating and translating the activated mobile intrusion detector zones associated with the mobile intrusion detectors detecting the potential intrusion into the mobile coverage map; (13) assigning a value to each of the mobile intrusion detector coverage zones associated with the mobile intrusion detectors detecting the potential intrusion to a predetermined value; (14) correlating the fixed intrusion detector coverage map with the mobile intrusion detector coverage map for each location within the mobile intrusion detector coverage zone which intersects the interior of one or more fixed intrusion detector sensor zones associated with a fixed intrusion detector detecting the potential intrusion to produce a weighted sum representing a probability of an intrusion by: (15) determining a maximum fixed intrusion detector threat score corresponding to the activated fixed intrusion detectors; (16) determining a composite global threat score by summing the mobile intrusion detector threat score and the maximum intrusion fixed sensor threat score; and (17) providing an alarm signal to an alarm output device if the composite global threat score is greater that the threshold value.

Another advantage of the invention is that it provides geographic correlation of fixed and mobile sensor alarm data. A further advantage is that it provides a high probability of detection with a low nuisance alarm rate by assigning "weights" to data representing intrusion detector outputs.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of the present invention.

FIG. 2 is a more detailed block diagram of the present invention.

FIGS. 3A and 3B are a schematic diagram of the alarm interface unit.

FIG. 4 is a block diagram of the mobile robot.

FIG. 5 is a functional block diagram of the sonar subsystem.

FIG. 6 is a perspective view of the autonomous vehicle used in conjunction with the present invention.

FIG. 7 is a perspective view of the propulsion module.

FIG. 8 is a schematic electrical diagram of the multiplexer portion depicted in FIG. 5 of the present invention.

FIG. 9 is a schematic electrical diagram of the transducer switching relay (Detail A) of FIG. 8.

FIG. 10 are flowcharts of the function of the controlling processor associated with the sonar system of the present invention.

FIG. 11 is a block diagram of the acoustic detection array.

FIG. 12 is schematic diagram of the amplifier/detector circuit of the acoustic detection array.

FIG. 13 is an example of an environment in which the present invention may operate.

FIG. 14 illustrates a path and obstacles obstructing the path of the vehicle within the environment presented in FIG. 13.

FIG. 15 is a three dimensional probability distribution plot showing the perceived location of nearby objects and obstacles within the environment illustrated in FIG. 14.

FIG. 16 is a flowchart of the Path (World) Planner program software.

FIG. 17 is a flowchart of the Find-Path program software.

FIG. 18 is a flowchart of the Expand program software.

FIG. 19 is a flowchart of the Retrace program software.

FIG. 20 is a flowchart of the Execute Path program software.

FIG. 21 is a flowchart of the Execute Segment program software.

FIG. 22 is a flowchart of the Map Sonar program Software.

FIG. 23 is a flowchart of the Local Assessment Software.

FIG. 24 is flowchart of the Update Sensor Software which is a subroutine of the software presented in FIG. 23.

FIG. 25 is a flowchart of the Assess Threat Software which is subroutine of the software presented in FIG. 23.

FIG. 26 is flowchart of the Adjust Weight Purposeful Motion Software which is a subroutine of the software presented in FIG. 25.

FIG. 27 is a flowchart of the Calculate Global Zone Weight Software which is a subroutine of the software presented in FIG. 25.

FIG. 28 is a flowchart of the Adjust Weight Angular Sensor Fusion Software which is a subroutine of the software presented in FIG. 25.

FIG. 29 is a flowchart of the Calculate Threat Software which is a subroutine of the software presented in FIG. 25.

FIG. 30 illustrates the intrusion detection coverage zones of the mobile robot.

FIG. 31 illustrates a plan view of the secured environment as presented on a video display and sensor output data.

FIG. 32 is a flowchart of software for initializing the fixed sensor coverage map.

FIG. 33 is a flowchart of software for performing threat assessment.

FIG. 34 is a flowchart of software for inhibiting the fixed sensors.

FIGS. 35A and 35B present a flowchart of software for performing fixed and mobile sensor output correlation.

FIG. 36 is a flowchart of software for adjusting the weights of the bits corresponding to the sensor outputs.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention provides an intrusion detection system which synthesizes data provided by one or more groups of intrusion detectors mounted on mobile robots with data provided by a fixed intrusion detection system in order to compile a composite intrusion threat level of an environment which is to be secured. A composite intrusion threat level exceeding a specified threshold results in an intrusion alert.

An overview of the present invention is described with reference to FIG. 1, where there is shown fixed sensor system **12** which preferably includes a multiplicity of different types of intrusion detectors that provide outputs to host computer **14** through alarm interface unit **16**. The invention also includes one or more security sensor systems **19** each mounted on a mobile robot **18** which patrols throughout the environment. Security sensor systems **19** are communicatively linked to host computer **14** via radio frequency link **20** Algorithms implemented by software in host computer **14** integrate the outputs of fixed sensor system **12** and security sensor system **19** in order to determine the composite intrusion threat level. If the composite intrusion threat level exceeds a predetermined threshold value, an alert signal is output from host computer **14** through alarm interface unit **16** to enable alarm system **22**. A human operator monitoring alarm system **22** then may appropriately respond.

This invention also provides navigational control for the mobile robots **18** which: 1) periodically identifies the location and orientation of the mobile robot, 2) plans a path for the robot to follow from its present location to a specified destination, and 3) provides directions to the mobile robot so that the path is executed in a manner whereby the mobile robot avoids running into anything.

A more detailed description of the present invention is presented with reference to FIG. 2. Fixed sensor system **12** may include several different types of sensors, as for example, door closure sensor **12***a*, window closure sensor **12***b*, microwave area sensor **12***c*, break-beam sensor **12***d*, passive infrared sensor **12***e*, pressure mat **12***f*, and video motion detector system **12***g*, comprising video camera $\mathbf{12}g_1$ and video motion detector $\mathbf{12}g_2$. Such sensors are well known and commercially available. However, in the preferred embodiment, video motion detector $\mathbf{12}g_2$ is of the type described in in U.S. Pat. No. 5,034,817 (application Ser. No. 07/486,465), Reconfigurable Video Line Digitizer And Method For Storing Predetermined Lines Of A Composite Video Signal, filed Feb. 28, 1990, incorporated herein by reference.

Referring still to FIG. 2, the video signal output from video motion detector system **12***g* is provided to video multiplexer (MUX) **24** and then is received by video recorder (VCR) **26** and displayed on video monitor **28**. RF link **20** includes RF link **20***a* coupled to host computer **14**, RF data transmitter $\mathbf{20}b_1$ mounted onboard mobile robot **18**, and RF video transmitter $\mathbf{20}b_2$, also mounted on mobile robot **18**. The video signal provided by video link $\mathbf{20}b_2$ is received by video receiver **20***c*, directed to MUX **24**, and optionally stored by VCR **26** and displayed by video monitor **28**. Alarm system **22** provides an alert signal when the outputs of fixed sensor system **12** and/or sensor system **19** detect perturbations within the secured environment that have a high probability of corresponding to an intrusion. Each of these major systems are described in greater detail further herein.

Fixed Intrusion Detection System

Fixed intrusion detection system **12** includes a multiplicity of sensors capable of detecting perturbations within the area to be secured that may correspond to intrusions caused by entry of unauthorized personnel or to other conditions inimical to the security of the area, as for example, fire. The sensors are positioned at fixed locations throughout the area to be secured in order to provide a high probability of detecting any such disturbances, as would be well known by those skilled in this art.

The outputs of the sensors which comprise intrusion detection system **12** are received by alarm interface unit **16** which routes them to host computer **14**. Computer **14** evaluates the data, and if an intrusion is detected, outputs an intrusion alert via alarm interface unit (AIU) **16** so as to enable alarm system **22**.

Alarm System

Alarm system **22** includes an annunciation device, such as a bell or siren, and a panel of indicator lights which show the status of the individual sensors of fixed sensor system **12**. Such light panels are well known and commonly employed in the security industry. Alarm system **22** responds to the various signals provided by alarm interface unit **16**.

Alarm Interface Unit

Alarm interface unit (AIU) **16** is intended to make the present invention compatible with existing installation security systems consisting principally of an alarm system **22** and a plurality of fixed sensors such as are depicted in FIG. 2 as sensors $\mathbf{12}_{a-g}$. AIU **16** provides an interface to host computer **14** which allows the host computer to ascertain the status (alarmed or clear) of the individual fixed sensors $\mathbf{12}_{a-g}$. In addition, AIU **22** provides an output interface which allows host computer **14** to relay this status information to alarm system **22**. AIU also provides an output signal via the VCR control line which allows host computer **14** to start and stop VCR **26**, and an output signal via a video MUX control line which allows control of video multiplexer **24**.

AIU **16** is described with reference to FIGS. 3A and 3B. AIU **16** has, by way of example, 16 inputs on each of two IC's 4067, 8 outputs from each of four IC's

74LS244, and is connected to the 8-bit parallel printer port of host computer **14**. In order for AIU **16** to control 32 inputs and 32 outputs, it uses five bits (DB0-DB4) from the standard 8-bit parallel PC printer port as address bits. Pin number, data bit, and function of each bit are listed in TABLE 1. Bit DB5 is used to determine if AIU **16** is reading or writing (input/output). The DB6 (DATA_OUT) bit outputs data, while the ACK (DATA_IN) bit is used for receiving data.

TABLE 1

BIT	PIN NUMBER	FUNCTION
DB0	2	OUTA0
DB1	3	OUTA1
DB2	4	OUTA2
DB3	5	SELA
DB4	6	SELB
DB5	·7	WR/RD
DB6	8	DATA_OUT
−ACK	10	DATA_IN

In order to send a data bit to one of 32 outputs, the WR/RD (DB5) line is set to a logic high. DB0-DB2 (OUTA0-OUTA2) provide the lower three output address lines. Since the 74LS259 addressable latch only has three input address lines and 8 outputs, a dual 2-to-4 74LS139 multiplexer is employed to allow four 74LS259 chips to be accessed, as determined by appropriate logic levels provided by DB3 (SELA) and DB4 (SELB). Each output from the 74LS139 is connected to the ENABLE input of one of the four 74LS259 multiplexer chips. The logic level of SELA and SELB thus determine which one of the four 74LS259 is enabled. OUTA0-OUTA2 then provide the necessary address to select the desired output port on the enabled 74LS259, whereupon13DATA OUT determines the logic level of that selected port. Once an output port state is set, it will retain the same value even after another port is selected. The value of an output port can only be changed if its corresponding address is set on lines DB0-DB4, otherwise the port value remains the same.

In order to read in an input from AIU **16**, the WR/RD line (DB5) is set to a logic low. OUTA0-SELA are used as the lower four address lines. The logic level of SELB, connected to 74LS139, determines which of the two 4067 analog multiplexers is enabled. If SELA is low, then ports **1-16** are available, whereas if SELB is high, then ports **17-32** are selected.

Programming required to control the operation of AIU **16** is implemented in host computer **14** and may be written in "C", as presented, by way of example, in Appendix 1.

Mobile Robot

Referring to FIG. **4**, mobile robot **18** is a mobile platform which includes local processor **402**, propulsion module **416**, sensor system **19**, and collision avoidance system **450**. Propulsion module **416** receives instructions from host computer **1** that direct it along a particular path. Collision avoidance system **450** provides data to host computer **14** via local processor **402** for indicating the presence of obstacles that may obstruct the path of mobile robot **18**. More detailed descriptions of each of these systems which comprise mobile robot **18** are presented further herein. Mobile robot **18** is capable of being navigated throughout the operating environment by instructions provided by host computer **14** through local processor **402**. Techniques for navigating a mobile platform in the manner employed in the preferred embodiment of the present invention are well known by those skilled in this technology, and are incorporated into a number of commercially available units. [Refer to U.S. Pat. No. 4,811,228, Method of Navigating An Automated Guided Vehicle, incorporated herein by reference].

Local Processor

Local processor **402** performs the following functions: 1) coordinates the operations of all of the systems of mobile robot **18**; 2) receives high level instructions from host computer **14**; 3) passes drive commands to propulsion module **416**; 4) receives X-Y position and heading updates from processor **417** of propulsion module **416**; 5) receives range and bearing data representing the area surrounding mobile robot **18** from processor **532** (See FIG. **5**); 6) checks for potential collision conditions; 7) sends stop commands to propulsion module **416** if a collision is eminent; and 8) passes required positional and sonar information to host computer **14**.

Local processor **402** may be programmed to perform the above recited functions in a high level language such as "C", or in an assembly language, such as 6502, in accordance with well known techniques, as set forth, by way of example, in Appendix 2.

Propulsion Module

Referring to FIGS. **6** and **7**, mobility and dead-reckoning position determination of mobile robot **18** depends on two degree-of-freedom, computer-controlled propulsion module **416** having motion directed by local processor **402** which is mounted on mobile robot **18**. Local processor **402** provides output instructions to processor **417** (FIG. **2**) of propulsion module **416** in response to data received from host computer **14** so that mobile robot **18** may follow a path calculated by host computer **14**. Processor **417** is typically provided as a component of commercially available propulsion modules of the type employed in the preferred embodiment of the present invention.

Commands are passed by local processor **402** to processor **417** which controls propulsion module **416** over a serial or parallel bus as a series of hexadecimal bytes which specify: (1) the direction in which to move or pivot, (2) the velocity, and, (3) the duration (distance or number of degrees.) The functions of propulsion module **416** include executing movement commands received from local processor **402** and performing dead-reckoning calculations. In an example of the preferred embodiment, these commands are:

Byte 1 - Type Motion Requested (00 to 07)

00 - Move forward
01 - Move reverse
02 - Pivot left
03 - Pivot right
04 - Offset left
05 - Offset right
07 - Stop

Byte 2 - Requested Velocity
Upper nibble is the port motor velocity;
Lower nibble is the starboard motor velocity.
Byte 3 - Distance to Move (Inches) or,
Duration of Pivot (Degrees) or,
Amount of Offset (Tenths of Degrees)

Velocity control and acceleration/deceleration ramping are performed by processor **417** on an interrupt basis, while the main code performs all dead reckoning

calculations. Cumulative X and Y components of displacement as well as current heading, θ, are passed up the hierarchy via local processor **402** at recurring intervals so that host computer **14** knows the location of mobile robot **18** in order to integrate data from sonar system **435** into a world model which is constantly being updated with new information. The programming which enables local processor **402** to control propulsion module **416** is typically provided with commercially available propulsion modules similar to the type described above. Examples of commercial models of suitable propulsion modules are the "LABMATE," manufactured by Transitions Research Corporation, 15 Great Pasture Road, Danbury, Conn. 06810, or the "NAVMASTER" by Cybermotion, 5457 Aerospace Road, Roanoke, Virginia, 24014.

Referring to FIGS. **6** and **7**, by way of example, propulsion module **416** includes a pair (only one wheel is shown) of coaxially aligned wheels **422** which are each driven by separate motors **424** which enable propulsion module **416** to be differentially steered by rotating each wheel **422** by different amounts, both in angular displacement and direction. Wheels **422**, may for example, have 8-inch rubber tires, which when coupled with motors **424**, provide a quiet, powerful propulsion system with minimal wheel slippage. Passive casters **423** mounted to propulsion module **416** provide it with stability. Armature shafts **428** of motors **424** are each coupled to a high-resolution optical rotary shaft encoder **426** that provides phase-quadrature, square-wave outputs, where each square-wave output corresponds to a specific increment of angular displacement of a wheel **422**. By way of example only, in the preferred embodiment, encoders **426** produce 200 counts per revolution of armature shaft **428**, which translates to 9725 counts per wheel revolution. Commands from local processor **402** direct the kinematics of propulsion module **416**, as for example, heading, velocity, and acceleration. Processor **417** (FIG. **2**) of propulsion module **416** provides host computer **14** with its instantaneously computed dead-reckoning position and heading which is calculated by counting the number and discerning the phase relationships of the square-wave outputs of each encoder associated with each wheel **422**. Power to operate mobile robot **18** is provided by battery **430** in accordance with well known techniques.

Collision Avoidance System

Collision avoidance system **450** (see FIGS. **4–5**) is used to detect obstacles in the path of mobile robot **18** and provide data to host computer **14** so that the path planner program can endeavor to calculate a path which avoids any detected obstacles. Referring to FIGS. **5**, **8** and **9**, collision avoidance system **450** includes processor **532**, multiplexer **534a** and transducer array **536a**. Processor **532** of collision avoidance system **450** receives commands from local processor **402** and provides ranges and bearings, detected by transducer array **536a**, from mobile robot **18** to nearby detected surfaces that may present obstacles in the path of mobile robot **404**. When an obstacle is detected within 5 feet of mobile robot **18**, host computer **14** updates the world model, as will be described further herein, using target range information provided by processor **532** through local processor **402** to host computer **14**. This range information is combined with additional information describing the heading, θ, of mobile robot **18** as well as X–Y position data. If local processor **402** determines that any range reading is less than some critical threshold distance (as for example, 18 inches in the preferred embodiment), indicative of an imminent collision between mobile robot **18** and an obstacle, then local processor **402** sends a "halt" command to processor **417** (FIG. **4**) of mobile robot propulsion system **416**, and informs host computer **14** of this action. The path planner, implemented in host computer **14**, then calculates a new path for mobile robot **18** to follow that avoids the obstacle so that mobile robot **18** may proceed to the predetermined location. Collision avoidance system **450** employs a multitude of pre-positioned ultrasonic transducers **536**: (FIG. **6**) that are individually activated in any desired sequence by processor **532**, thus enabling collision avoidance system **450** to obtain range information in any given direction within an arc centered at the front of mobile robot **18** that extends forward in a 120 degree conical pattern. Such ultrasonic transducers are commercially available from the Polaroid Corporation.

Still referring to FIGS. **5**, **8** and **9**, the preferred embodiment of collision avoidance system **450** includes transducer array **536a**, which may for example, consist of 7 active ultrasonic ranging sensors **536_i**, where i equals 1 to 7, with individual 30 degree beam widths, spaced 15 degrees apart in an arc around the front of mobile robot **18**, as shown in FIG. **6**. Processor **532** receives commands from local processor **402** and is operably coupled to multiplexer **534a** having outputs that selectively and sequentially activate transducers **536_i** in accordance with instructions provided by processor **532**.

The details of multiplexer **534a** are illustrated generally in FIGS. **8** and **9**. The seven ultrasonic transducers **536_i** are interfaced to ultrasonic ranging module **548** through 12-channel multiplexer **534a**, in such a way that only one transducer, **536_i**, is fired at a time. The ultrasonic ranging module **548** may be a "Texas Instruments" ranging module, Model No. SN28827, as is well known. The heart of multiplexer **534a** is a 4067 analog switch shown in FIG. **4**. Processor **532** thus "sees" only one transducer **536_i** at a time through ranging module **548** and multiplexer **534a**, and the software of processor **532** merely executes in a loop, each time incrementing the index which thus enables a specific transducer **536_i** of transducer array **536a**.

Ultrasonic ranging module **548**, if implemented with Polaroid Model No. SN28827, is an active time-of-flight device developed for automatic camera focusing, and determines the range to target by measuring elapsed time between the transmission of a "chirp" of pulses and the detected echo. The "chirp" is of one millisecond duration and consists of four discrete frequencies transmitted back-to-back: 8 cycles at 60 kHz, 8 cycles at 56 kHz, 16 cycles at 52.5 kHz, and 24 cycles at 49.41 kHz.

To simplify the circuitry involved, all timing and time-to-distance conversions are done in software on processor **532**. Three control lines are involved in the interface of the ultrasonic circuit board **548** to processor **532**. The first of these, referred to as VSW, initiates operation when brought high to +5 volts. A second line labelled XLOG signals the start of pulse transmission, while the line labelled MFLOG indicates detection of the first echo. Processor **532** must therefore send VSW high, monitor the state of XLOG and commence timing when transmission begins (approximately 5 milliseconds later), and then poll MFLOG until an echo is detected or sufficient time elapses to indicate there is no echo.

Four input/output (I/O) lines from processing unit **532** handle the switching function of ultrasonic transducers **5361**$_i$ by activating a 4067 analog switch **544**. The binary number placed on these I/O lines by the central processing unit **532** determines which channel is selected by switch **544**; all other channels assume a high impedance state. Referring to FIG. **9**, each of the relays **576** and its associated driver transistor **572** (illustrated in FIG. **8** as Detail A) is substantially identical. Relay driver transistor **572** is biased into conduction by current limiting resistor **543** via the active channel of analog switch **544** in such a fashion such that only one transistor **572** per switch **544** is conducting at any given time, as determined by the binary number present at the outputs of buffers **537**, **538**, **540**, and **542**. This conducting transistor **572** sinks current through its associated relay coil of relay **576**, closing the contacts of relay **576**. This action causes one of the transducers in array **536** to be connected to and hence driven by the ultrasonic ranging module **548**, when ultrasonic ranging module **548** is activated by central processing unit **532** as described below.

Three I/O lines carry the logic inputs to processor **532** from the ranging module **548** for XLOG and MFLOG, and from processor **532** to the ranging module **548** for VSW. Non-inverting buffer **568** is used to trigger switching transistor **562** upon command from central processing unit **532** to initiate the firing sequence of ranging module **548**. Resistors **558** and **560** along with transistor **556** form an inverting buffer for the XLOG signal which indicates the actual start of pulse transmission. Resistors **552** and **554** along with transistor **550** form an inverting buffer for the MFLOG signal which indicates detection of the echo. A final I/O line from processor **532** activates power switch **533**, shown in FIG. **5**, to power down the circuitry when not in use to save battery power.

A second parallel port on processor **532** is used to receive commands from local processor **402** which tell processor **532** to power up the ranging units, and then, which sensors to sequentially activate. Commands may be in the form of an eight-bit binary number represented in hexadecimal format, where the upper nibble represents the starting ID and the lower nibble the ending ID for the sequence. For example, the command $17 can be used to activate and take ranges using sensors #1 through #7 sequentially. Each time through the loop, upon completion of the sequence, the stored ranges are transmitted up the hierarchy to the local processor **402** over an RS-232 serial link, with appropriate handshaking. The sequence is repeated in similar fashion until such time as the local processor **402** sends a new command down, or advises central processing unit **532** to power down the ranging subsystem with the special command $FF.

The software of processor **532** may, by way of example, be structured as shown in FIG. **10**. When energized by the local processor **402**, processor **532** does a power-on reset, initializes all ports and registers, and then waits for a command. When a command is latched into the I/O port, a flag is set automatically that alerts processor **532**, which then reads the command and determines the starting and ending identities of the transducers **536**$_i$ to be sequentially activated. The interface circuitry and ranging units are then powered up, via switch **533** (FIG. **5**) and the Y Register is set to the value of the first transducer to be fired.

Referring to FIG. **10** and continuing the example, Subroutine PING then is called, which enables the particular channel of analog switch **544** dictated by the contents of the Y Register. The VSW control line is sent high, which initiates operation of the ranging module **548** with the selected transducer. The software then watches the multiplexer output XLOG for indication of pulse transmission, before initiating the timing sequence. The contents of the timing counter, representing elapsed time, can be used to calculate range to the target. If this value ever exceeds the maximum specified range of the subsystem, the software will exit the loop, otherwise the counter runs until MFLOG is observed to go high, indicating echo detection. Upon exit from the timing loop, the range value for that particular transducer is saved in indexed storage, and Subroutine PING returns to the main program.

The Y Register is then incremented to enable the next ranging module in the sequence, and Subroutine PING is called again as before. This process is repeated until the Y Register equals the value of the ending index, signifying that all transducers in the sequence specified by the local processor **402** have been activated individually. Processor **532** then requests permission from the local processor **402** to transmit all the stored range values via the

RS-232 serial link. When acknowledged, the ranges are sequentially dumped out the serial interface and placed by the local processor **402** in Page Zero indexed storage. Upon completion, processor **532** checks to see if a new command has been sent down altering the ranging sequence, and then repeats the process using the appropriate starting and ending indexes. Thus the software runs continuously in a repetitive fashion, sequentially activating the specified ranging modules, converting elapsed time to distance, storing the individual results, and then finally transmitting all range data at once to the local processor **402**, which is thus freed from all associated overhead. Securitv Sensor System

Referring to FIGS. **4** and **6**, security sensor system **19** is mounted to propulsion module **416** and includes a multiplicity of different types of sensors capable f detecting perturbations within the secured environment of the type associated with an intrusion. In the preferred embodiment, sensor system **19** includes acoustical detection system **19*a***, vibration sensor **19*b***, infrared motion detector system **19*c***, microwave motion detector system **19*d***, optical motion detector system **19*e***, ultrasonic detector system **19*f***, video motion detector system **12**g_1, and acoustical monitoring system **19*i***. The outputs of these sensor are all provided to local processor **402** and then ultimately to host computer **14** which processes the information provided by the various sensors. Video camera **12**g_1 is mounted on head positioning servo **19*j*** which is controlled by host computer **14** by techniques well known by those skilled in this art. Host computer **14** provides control signals to head positioning servo **19*j*** in order to adjust the visual field of view of video camera **12**g_1, based on the perceived threat location, as discussed further herein. The outputs of acoustical monitoring microphone **19*i*** and video camera **12**g_1 are provided to video transmitter **20**b_2.

Ultrasonic Motion Detection System

Ultrasonic motion detection system **19*f*** may be used to scan the environment in which mobile robot **18** operates in order to identify a potential intrusion through changes in measured target distances as seen by one or

more sensors in the 24-element array. The system creates a reference template, which consists of the two most frequently observed range values for each of the individual sensors in the array, and then compares subsequent readings to this template. The presence of an intruder within the system field of view will result in a range value which does not agree with the two possibilities recorded earlier in the reference template. The new range reading will correspond to the distance to the intruder, and the index (position) of the affected sensor within the 360-degree array will provide a relative bearing, which is then used by the host computer to plot the position of the suspected intruder on the map display. Referring to FIGS. **5**, **8** and **9**, ultrasonic motion detection system **19***f* includes processor **532**, multiplexers **534***b* and **534***c*, and transducer arrays **536***b* and **536***c*. By way of example, transducer arrays **536***b* and **536***c* each may include twelve ultrasonic transducers which are mounted in a 360 degree circular pattern around the top of mobile robot **18** as shown in FIG. **6**. For purposes of reference, the twelve ultrasonic transducers of array **536***b* may be referenced as ultrasonic transducers **536**$_i$, where i=1 to 12; and the twelve ultrasonic transducers of array **536***c* may be referenced as ultrasonic transducers **536**$_i$, where i=13 to 24. All ultrasonic transducers **536**$_i$ may be of an identical type.

Ultrasonic motion detection system **19***f* performs ranging in a manner that is virtually identical to the way in which collision avoidance system **450** operates. The only difference between the hardware implementations of the two systems is that ultrasonic detection system **19***f* includes two multiplexers and 24 ultrasonic transducers, whereas collision avoidance system **450** employs one multiplexer and seven ultrasonic transducers. Therefore, it is to be understood that the descriptions of multiplexer **534***a* and transducer array **536***a*, illustrated and described with respect to FIGS. **5**, **8** and **9**, also apply to multiplexers **534***b* and **534***c*, and to transducer arrays **536***b* and **536***c*. Processor **532** interacts with multiplexers **534***b* and **534***c* in the same manner as processor **532** interacted with multiplexer **534***a*. Furthermore, the data generated by ultrasonic detection system **19***f* is provided through local processor **402** to host computer **14**.

Optical Motion Detection System

Optical motion detection system **19***e* may be of any suitable type of commercially available optical motion detector. An example of an optical motion detectors suitable for use in the present invention is that described in U.S. Pat. No. 4,902,887, "Optical Motion Detector Detecting Visible And Near Infrared Light", incorporated herein by reference. Another type of optical motion detector suitable for use in the present invention is manufactured by Sprague, Model No. ULN-2232A.

Infrared Motion Detector System

Infrared motion detector system **19***c* is, by way of example, similar in operation to the Sprague Model No. ULN-2232A, identified above, except that a wavelength of 10 micrometers is used. Examples of infrared motion detectors suitable for employment in the present invention include the passive infrared sensing system manufactured by Eltec Instruments, Inc., Model No.'s 822, 826B and 4192-3, as well as passive infrared detectors manufactured by Linear Corporation, Series 6000, 8000, and 9000.

Microwave Motion Detection System

Microwave motions detectors such as employed in microwave motion detector system **19***d* are well known. Such detectors rely on the Doppler shift introduced by a moving target to sense the relative motion of an intruder. The electromagnetic energy associated with such detectors can penetrate hollow walls and doorways thereby allowing the sensor to "see" into adjoining rooms in certain circumstances. This operating feature permits the sensor to check locked office spaces and warehouses without the need for actual entry into such places.

Acoustical Monitoring Microphone

Acoustical monitoring microphone **19***i* is described in U.S. Pat. No. 4,857,912, "Intelligent Security Assessment System", column 6, lines 30–41, incorporated herein by reference.

Vibration Sensor

Vibration sensor **19***b* may be implemented similarly to acoustical monitoring microphone **19***i* except that a piezoelectric transducer, mechanically coupled to the structure of the robot **18**, is used instead of a microphone such that the vibrations in the floor of the secured environment such as ma be caused by a potential intruder are coupled to the detection unit.

Acoustical Detection System

Acoustical detection system **19***a* is described with reference to FIGS. **4**, **6**, **11** and **12**. This system provides bearing information to the source of detected noise and includes three acoustic sensor elements configured as shown in passive array **455**, each operably coupled to an amplifier/detector circuit **457**, shown in detail in FIG. **11**. The outputs of the three amplifier/detector circuits are provided to acoustic processor **458** which may be a 6502 based, single board computer. Array **455** consists of three omnidirectional microphones **459** symmetrically oriented 120 degrees apart, and separated by a distance d, not shown. This system is mounted on top of robot **18** as shown in FIGS. **4** and **6**. Sound traveling across array **455** triggers all three microphones **459** in a specific sequence dependent on the relative position of the acoustical source with respect to an array **455**. Because of the symmetrical orientation of microphones **459**, the firing sequence of comparators **339** associated with each microphone **459** is used to determine the bearing to the acoustical source through simple triangulation. Such passive acoustical surveillance schemes are well known by those skilled in this technology.

Video Motion Detection System

Video motion detection system **19***g* includes video surveillance camera **19***h* and video motion detection system **19***g*. The orientation of video surveillance camera **19***h* is controlled by head positioning servo **19***j*. Head positioning servos suitable for use in the present invention are well known and commercially available. Video motion detection system **19***g* is preferably of the type described in application Ser. No. 07/486,465, "Reconfigurable Video Line Digitizer And Method For Storing Predetermined Lines Of A Composite Video Signal", filed Feb. 28, 1990, incorporated herein by reference. Video camera **19***h* is further positioned to bear on the intruder using refined analysis by the output of video motion detection system **19***g* if the intruder's

presence is detected by video motion analysis. Video motion detection system **19**g is temporarily disabled as head positioning servo **19**j pans to reposition camera **19**h, and is re-enabled once the camera stabilizes. Software which provides the video motion analysis used to orient camera **19**h is provided in Appendix 3, written by way of example, in 6502 assembly language.

Host Computer

Host computer **14** performs the functions of building and maintaining the "world model", a mathematical representation of the operating environment; performing path planning to generate the initial route of mobile robot **18**; rerouting mobile robot **18** to avoid obstacles in its path; formulating a composite intrusion threat score based on data provided by fixed sensors **12** and mobile security sensor system **19**; and providing an operator interface. Host computer **14** may be, by way of example, a 16-bit Intel 80386-based personal computer. Host computer **14** is programmed in a high level language such as "C". By way of example, the more significant source code program listings of software required to operate the present invention are described below. These and other software implemented in the present invention are identified in Appendix 1, herein. Program listings for software identified in Appendix 1 are provided in Appendix 2, herein.

World Model

Providing the capability of supporting autonomous movement of a mobile robot involves the acquisition of information regarding ranges and bearings to nearby objects, and the subsequent interpretation of that data in building and maintaining the world model. The world map is a two-dimensional array of cells, where each cell in the array corresponds to a particular square having fixed dimensions in the region being mapped. Free space is indicated with a cell value of zero; a non-zero cell value indicates the presence of an object. The cell value represents the probability of a given square being occupied, which is useful when the precise location of an object is unknown.

The acquisition of range data is accomplished by use of collision avoidance system **450**. Target distance information is ultimately provided to host computer **14** which assimilates the data into the world model while mobile robot **18** is moving. Effective interpretation and utilization of range data is critical to achieve a reasonably accurate representation of surrounding obstacles. By using a simplified probability scheme and range gating fixed arrays of sonar sensors, the mapping process can take place in real-time while mobile robot **18** is in motion. FIG. **13** is a plan view of an example of an operating environment **600**, or "world," which for purposes of illustration, may be a two-room laboratory, where the perimeter of the environment is composed of wall segments **602, 604, 606, 608, 610**, and **612**. Furthermore, by way of example to illustrate how the world map is constructed, environment **600** may also include interior walls **614** and **616**; doorway **618**; book shelves **620** and **622**; file cabinet **624**; and tables **626, 628, 630, 632**, and **634**. The world map may be manually edited to add additional features, such as hidden lines, doorways, etc. Each object in the world model then is automatically "grown" by half the width of mobile robot **18** in order to model the mobile robot as a point during the Find-Path operation, described further within this section. This growth is represented by the outer perimeter **636** of operating environment **600**.

When entering data from collision avoidance system **450**, seven ultrasonic ranging transducers **536**$_i$ (where $i=1$ to 7) in transducer array **536**a are used, shown in FIGS. **5, 6** and **8**. If a given transducer **536** return (echo) shows that an object is within five feet of array **536**a, the cell at the indicated location of the return is incremented twice (up to a specified maximum). Also, the probability value assigned to each of the eight neighboring cells is incremented once, to partially take into account uncertainties arising from the 30-degree dispersion angle of the ultrasonic beam generated by array **536**a.

In addition, each time a return is processed, all the cells within a cone, which may by way of example, be **10** degrees wide and five feet long (or less if an object appears within five feet), have their assigned values decremented by 1. This erodes objects from the world map that are no longer present and serves to refine the representation of existing objects as mobile robot **18** approaches. Objects are erased from the map at a slower rate than they are entered, so that the path of mobile robot **18** tends to err on the side of not intersecting obstructions.

An example of how data provided by collision avoidance system **450** may be transformed into a mathematical model of one example of an operating environment, such as environment **600**, is presented in FIG. **14**, where a path **638** from point A to point B, along which mobile robot **18** (not shown) may be directed to follow, is obstructed by two obstacles **640**. Other objects **642, 644**, and **646** are also positioned within environment **600**. A three dimensional probability distribution plot showing the perceived location of nearby objects in environment **600** is illustrated in FIG. **15**. The floor area of environment area **600** is represented by cells ("nodes") **650**. The probability that any particular cell is occupied by an object is proportional to the upward projection of any cell along the "Z" axis. Techniques for creating world maps of an operating environment or "motion area," suitable for use in the present invention are well known. The world map contains positional information about all the known objects in the environment.

One method for generating the initial world map is to download data into host computer **14**, where the data represents the operating environment, and is obtained from CAD drawings such as AutoCAD, a designing program by which any drawing, such as a building floorplan can be reproduced in a microcomputer. A second method is to manually input data into the host computer where the data represents the coordinates of the features of the environment using the MAPEDIT.C subroutine (Appendix 1). A third method for generating the world map is to have mobile robot **18** travel along its anticipated routes and use its sonar system **440** to generate data regarding the features of the environment that are then provided to host computer **14**. Also, a combination of all three methods may be employed to create or modify the world model.

The path planner operates on information stored in the world map to determine a route from the mobile robot's current position to its desired destination. The basic search algorithm begins by "expanding" the initial cell corresponding to the mobile robot's current position in the floor map, i.e., each unoccupied neighbor cell is added to the "expansion list." Then each cell on the expansion list is expanded. This process continues

until the destination cell is placed on the expansion list, or the list becomes empty, in which case no path exists.

When a cell is placed on the expansion list, a value indicating the direction to the parent cell is stored in the map array. Once the destination cell has been reached, retracing the path consists of merely following the directional arrows back to the source. During this process, only those points representing a change in direction (an inflection point) are recorded. The entire path is completely specified by the straight line segments connecting these inflection points. Details of the path planner are presented below.

Path Planner

The path planner (See Appendix 1, PATHPLAN.C) is implemented as a set of algorithms running on host computer **14** which enables mobile robot **18** to be directed along a calculated path from the present position of mobile robot **18** to a different position, where the positions are defined by Cartesian coordinates. Implementation of the path planner is, by way of example, a modification of techniques taught in: Winston, Patrick Henry, *Artificial Intelligence*, Addison-Wesley, Reading, Mass., 1984. However, it is to be understood that the scope of the invention may include other implementations of a path planner than those specifically presented herein.

There are four basic tasks the path planner must address in order to direct mobile robot **18** from point "A" to point "B". They are described immediately below with reference to FIG. **16**:

1. Finding a path to the destination (point B), hereafter referred to as the "Find-Path" operation at step **800**. If no path exists, then this operation returns a value of FALSE to the calling program.
2. Retracing (or backtracking) the path found by the above "Find-Path" operation (discussed more fully further herein) to create a list of straight-line segments describing the route from source to destination, where the source represents the present position (point A) of mobile robot **18**. This operation is performed at step **802**.
3. Creating the movement commands which are ultimately directed to propulsion module **416** via local processor **402** in order to execute the path. These operations are performed at step **804**.
4. If the path is successfully executed, then the path planner program returns a "successful" status from step **806** to the calling program. Otherwise, the program returns to step **800** in order to plan a new path.

Inability of mobile robot **18** to reach its intended destination is usually attributable to obstacles or closed doorways blocking the route. In that case, the planner returns to Step **800** to try to find a different path, using the updated information now encoded in the model.

The path planner includes the following subroutines: Find-Path, Expansion, Backtracking, Path-Execution, Segment-Execution, and Sonar-Mapping. These subroutines are described below.

Find-Path Subroutine

As mentioned above, the Find-Path subroutine at step **800** is a set of algorithms which implement a modification of an A* search which is described below with reference to FIG. **17**. The A* search is a type of search technique which is well known by those skilled in this art and which is taught in: Winston, Patrick Henry, *Artificial Intelligence*, Addison-Welsley, Reading, Mass., 1984. In the Find-Path subroutine, a mathematical model of the operating environment, also referred to the world map, is provided to this subroutine at step **807**. The environment is divided into a definite number of squares. The world map is implemented as a two dimensional array of memory locations, and contains a byte for each square in the environment, such as a room, where the size of a square can range from one square inch up to several square feet, depending on the desired map resolution and the size of the operating environment.

Next, at step **808** two special bytes are stored in this memory array which represents the world map. One byte indicates the present location ("START") of mobile robot **18**; the second byte indicates the desired destination ("DEST"). During the A* search process, the host computer **14** looks for the floor cell containing the DEST byte and similarly, during the backtrack process, described below, the computer looks for the START byte.

Next, at step **810**, information about the source cell (such as X-Y location, cost, distance traveled, etc.) is put onto a "frontier" list which is a list of points on the outer edge of the search envelope that are candidates for the "expansion" process, described more fully below. Putting the source cell on the frontier list "seeds" the path planner subroutine so that it has a cell to expand. A loop is then entered at step **812** that terminates only when there are no more cells on the frontier list or a path has been found. If the frontier list is empty, then no path is possible and the search fails.

The first step within the loop, at **814**, is to find all the cells on the frontier list with minimum cost, and then put them on the expansion list at step **816**. The "cost" of a cell is typically some computation of how "expensive" it is for mobile robot **18** to travel to the location represented by that particular cell. The actual cost function used in this implementation is described further herein.

Next, all the cells on the expansion list are expanded at step **818**, as described more fully in the next section. If the destination cell is reached, a path has been found and the algorithm terminates with a solution and returns to the calling program from step **820**. Otherwise, the loop continues with the new frontier list (updated by the expansion process).

Expansion Subroutine

Referring to FIG. **18**, the expansion process looks at all the neighbor cells of each cell on the expansion list. Each neighbor cell that is unoccupied and not on either the expansion or frontier list is placed on the frontier list. The details of this are provided below.

A loop is entered at step **822** that terminates when all the cells on the current expansion list have been expanded. If no cells are left on the list, then a value of FALSE is returned from step **824** to the path planner at step **818**, indicating that the destination was not reached during the current expansion and that further searching of the updated frontier list is necessary.

The next cell (or first cell if this is the first time through the loop beginning at step **822**) on the expansion list is selected. First, a check is made to see if this cell can be expanded. The only cells that can be expanded are those whose corresponding byte in the floor map array is equal to zero. If the value is not zero, this cell may be occupied by an obstacle which has been detected by the robot's sensors. If so, then the value is

decremented at step **826** and the cell is put back onto the frontier list at step **828** to be expanded later. This technique enables mobile robot **18** to travel a clear path in preference to a cluttered path, if a clear one exists. If no uncluttered path is found, mobile robot **18** may still be able to traverse the cluttered path. The capability of the expansion subroutine to determine alternative paths enables the robot to find a path even if sonar data provided by sonar system **418** is somewhat faulty.

If the contents of the current floor map cell are zero, then the cell can be expanded. Each of the cell's neighbors may be examined at steps **832**, or **834** to see if any of the neighbors are occupied or unoccupied. "Neighbor" in this case refers to the four cells immediately adjacent to the current cell, i.e., located to the north, east, south and west of the current cell. These four "neighbors" may also be referred to as the "4-connected" neighbors. If the neighbor contains the special byte "DEST," then a path has been found at step **832**, the X-Y location of the cell is saved at step **836**, and a "TRUE" status is returned from step **838** to step **818** of the Find-Path subroutine. Otherwise, if the neighbor cell is unoccupied it is placed on the frontier list at step **840**. If it is occupied, it is ignored.

Additionally, each cell has a "cost" associated with it. As in a typical A* search, at step **842**, the cost is set equal to the distance traveled from the initial position of mobile robot **18** in order to get to the cell corresponding to the present location of mobile robot **18**, plus the straight line distance to the destination cell. This is guaranteed to be less than or equal to the actual total distance from the source cell (present location) to the destination. This particular cost function tends to make the search expand in a direction towards the intended destination, thereby decreasing the search time.

Finally, "arrow" information, used by the backtracking subroutine, described below, is stored in the floor map cell corresponding to the current neighbor at step **846**. An "arrow" is one of four values indicating direction, i.e., north, south, east, and west. The arrow indicates the direction to the neighbor's parent, which is the cell currently being expanded.

Control is returned from step **840** to the top of the loop at step **822**.

Backtracking Subroutine

Referring to FIG. **19**, backtracking (also called retracing or segmentation) is a subroutine that creates a list of path segments which describe the desired path, based on the contents of the current floor map following the Find-Path operation, as described above. The procedure is very simple. Starting with the destination cell, the steps presented below are performed:

1. Follow the arrow in the current cell to the next cell. Make the new cell the current cell.
2. Return to the program that called the path planner if the new cell contains the value START, indicating that a path to the destination has been found.
3. Return to step **1**, above, if the direction arrow of the current cell is the same as the direction arrow of the previous cell.
4. Add the current X-Y coordinate to the path segment list and update the segment counter.

The output of the backtracking subroutine is a list of X-Y coordinates describing the "waypoints" through which mobile robot **18** must pass in order for the mobile robot **18** to reach the ultimate destination.

Path Execution Subroutine

Referring to FIG. **20**, once a path segment list has been found, mobile robot **18** must then physically traverse the calculated path to reach the destination. Each segment of the path is executed individually in a loop beginning at step **860**, whereby this process consists of having mobile robot **18** turn to the required heading and then having it travel in a straight line for a predetermined distance.

Control is passed to the segment execution routine at step **870**. A status condition is returned from step **871** to step **804** of the path planner, where the status condition indicates whether or not mobile robot **18** was able to successfully execute the segment. If it was successful, then the subroutine proceeds to step **860** where the next path segment (if any) is executed. Otherwise, an error condition is returned from step **871** to step **804** of the path planner.

Segment-Execution Subroutine

Referring to FIG. **21**, during the execution of a subroutine referred to as "Segment-Execution," the planner performs a number of tasks. First, step **872** sends a command to propulsion module **416** to begin moving forward for a predetermined distance required by the path segment. Next, "Segment-Execution" enters a loop at step **873** which looks for status packets sent back by local processor **402**. These consist of one or more of the following:

1. A "move complete" report, indicating that propulsion module **416** has finished moving the desired distance. If this occurs, an indication of successful status is returned by step **874** to step **870**, illustrated in FIG. **20**.
2. An "obstacle" report, indicating that propulsion module **416** has stopped because an obstacle detected by collision avoidance system **450** impedes its path is returned by step **875** to step **870**, illustrated in FIG. **20**.
3. A "dead-reckoning" update. The present dead-reckoned position of mobile robot **18** is updated in the world map at step **876**.
4. A collision avoidance sonar packet is provided when sonar data is received by local processor **402**, at which time the "sonar-mapping" subroutine, represented by the flowchart of FIG. **22**, is invoked and the current representation of the world map is updated at step **878**.

The loop beginning at step **873** is repeated until either of the steps **874** or **875** within the loop is executed.

Sonar-Mapping Subroutine

Referring to FIG. **22** map sonar is a subroutine that receives the range information obtained by collision avoidance system **450** which then is used to update the local map. Although in the preferred embodiment, range information is obtained by use of ultrasonic transducers **536*i***, other types of sensors could also be used to acquire such information, as for example, laser or optical range finders.

One of the primary sources of errors with ultrasonic sonars is specular reflection. In order to reduce the number of erroneous sensor readings due to these types of errors, all detected ranges greater than specified distance, which may for example, be five feet, are ignored. Whenever a range reading is five feet or less, the value of the cell at the indicated range and bearing is

incremented twice (up to some maximum, as for example, 16), and each of its 8-connected neighbors (all 4-connected neighbors plus each of the diagonals) is incremented once.

During the execution of the map sonar subroutine, sonar range returns or packets provided by processor **532** through local processor **402** to host computer **14** are processed and mapped. The sonar packets are decoded at step **880**. Then a loop is entered at step **881** that continues until each range has been processed. At step **882**, the range is compared with five feet. If the range is greater than five feet, then processing proceeds to step **884**. Otherwise, a transient obstacle will be added to the ma at step **883** by incrementing the appropriate cell (indicated by the current range and bearing) by two, and each of the eight surrounding cells by one. This is the manner in which transient obstacles are added to the map. In step **884**, all of the cells in a ten degree cone emanating from the location of the transducer out to the range return or four feet, whichever is less, are decremented by one. In this way, transient obstacles that are no longer detected are gradually erased from the map.

Collision Avoidance

For a mobile robot to be truly autonomous, it must cope with the classic problem of avoiding an unexpected, unmapped obstacle. In the present invention, all collision avoidance sensor information is statistically represented in the world map, based on the number of times that an object was detected at a given cell location [See APPENDIX 1: OA.C and CA.C]. Conversely, when a previously modeled object is no longer detected at its original position, the probability of occupancy for the associated cell is decreased; if the probability is reduced to zero, the cell is again regarded as free space. Transient objects are added to the world map as they are encountered, and subsequently removed from the model later if no longer detected at the same location. Since previously encountered obstacles are recorded in the world map, the mobile robot can avoid them at the planning stage rather than during path execution.

A sample map created in this fashion is depicted in FIG. **15**. Free space is represented by an array value of zero and is shown in by the plane coincident with the X-Y plane.

Data Fusion System

The data fusion system, implemented in software operating in host computer **14**, integrates the outputs of fixed security sensor system **12** and mobile security sensor system **19**, to obtain a higher confidence solution, and to ensure that the motions of mobile robots **18** through the secured environment do not trigger a system alarm. Referring to FIG. **23**, the individual security sensor values are updated as new sensor data becomes available, whereupon a composite threat score is calculated based on the updated sensor data. Data from both fixed and mobile sensors is used to calculate this global composite threat score from individual sensor weightings in order to achieve a high probability of detection with a corresponding low nuisance alarm rate.

The data fusion system "knows" at all times where each robot **18** is located, the zones of coverage for its onboard sensor system **19**, and the resultant effect of its presence or motion on that portion of fixed sensor system **12** viewing the same area. This information is incorporated into the world model, representing the area under surveillance, as discussed in greater detail below.

The world model consists of a number of bit-mapped parallel arrays, or layers, each indexed to an absolute X-Y grid representing the floor plan of the secured area (See Appendix 1: OA.C, MAPEDIT.C, and MAKEMAP.C). The floor plan is typically divided up into a number of subset floor plans to achieve a realistically sized model in order to facilitate near realtime manipulation of the encoded information. For any given subset floor plan, the first layer is devoted to X-Y positional information which is used for navigation and collision avoidance, as previously described.

Two additional parallel arrays, or layers, are assigned to the world model and are used to represent the areas of coverage of: (1) the fixed installation security sensors for that portion of the floor plan in which robot **18** is positioned, and (2) the mobile security sensors mounted on robot **18**. These two layers are referred to as the "fixed sensor coverage layer", and the "mobile sensor coverage layer".

Since the purpose of robot **18** is to patrol the secured environment, its position and orientation must be considered when calculating the absolute world map representations of the areas within the range of detection of mobile sensor system **19**. The representations must be translated and rotated in accordance with the robot's motion. The resulting mobile layer coverage zones can then be fused with those from the fixed sensor layer for those sensors which are triggered, resulting in a "fixed-mobile" correlation factor representative of the maximum correlation between fixed and mobile sensors. This factor is used to calculate the global composite threat.

In summary, the data fusion system (implemented in software) monitors the instantaneous state of each of the fixed and mobile security sensors to determine the presence or absence of an intruder. Local Security Assessment software implemented in local processor **402** onboard robot **18**, performs some "local" cross correlation of the outputs on sensor system **19**. Results are transmitted over RF link **20**b_1 to host computer **14** for further analysis. A higher level ("global") correlation, implemented in host computer **14**, then accounts for the outputs of fixed sensor system **12**, as well as the outputs from however many mobile robots **18** are operating in the area. This higher level correlation is referred to as Global Security Assessment (See FIG. **33**). Each of these assessment functions, local and global, are discussed in greater detail below.

Local Security Assessment

As previously stated, a number of different types of sensors are preferably used onboard each mobile robot **18** (as for example, infrared, microwave, ultrasonic, optical, video, sound, and vibration) to both increase the likelihood of detection and decrease the frequency of nuisance alarms. FIG. **23** illustrates, by way of example, a sample display **890** of video monitor **28** exhibiting the status of the various sensors. Techniques for producing such a display are well known by those skilled in this field of technology. The upper half of display **890** presents the state of each of the mobile sensors, the bearing to a possible intruder, and the current alarm state. Sensors with a darkened background are temporarily disabled or unavailable. The lower half of display **890** is used for displaying robot status information and current environmental conditions.

The motion detection sensors (depicted in the upper half of the display) are grouped into (24) zones. Each zone contains several different types of sensors. Local Security Assessment Software (Section 4.11 herein) performs a summation of weighted scores for all sensors within a particular zone, and calculates a composite threat score (Shown in the upper right of display **890**; Refer to FIG. **31**) which is proportional to the perceived threat presence. This software is implemented in host computer **14**, and presented by way of example in Appendix 1.

The Local Security Assessment Software detects patterns, such as purposeful motion across adjacent sensor coverage zones, and increases the associated composite threat accordingly. The system then activates and positions secondary verification sensors on the robot as needed. At the same time, the current alarm threshold is dynamically calculated, based on the number of sensor groups which are available, and other relevant conditions, such as ambient lighting, time of day, etc. The system classifies an alarm as an actual intrusion only when a complete evaluation has been performed using all sensor groups, and the resulting composite threat score exceeds the alarm threshold.

The Local Security Assessment Software uses an algorithm which employs a polar representation of the sensor data to establish a composite threat score for each of 24, 15 degree, wedge-shaped zones about mobile robot **18**, as shown in FIG. **25**. The Local Security Assessment Software, provided by way of example in Appendix 2, is written in 6502 assembly language. The human operator is alerted to any situation where the composite threat score exceeds the specific alarm thresholds for a given zone, as discussed in more detail later. A threat assessment value in the range of 0–100 is provided as a quantitative indicator of classification confidence, and a threat vector originating from the robot's current position is graphically displayed by host computer **14** on video display **15**.

Reading in the Data

On each pass through the Security Assessment Loop, (Refer to FIGS. **23-29**) individual sensors which are in an alarm condition are identified by the functions 'update_range_sen' and 'update_onoff_sen', (Refer to FIG. **24**; Appendix 1: ACCESS.C) which create an array of output values that are then stored in the current information fields of the data structure. The baseline weighting values for this operation are taken from a two-dimensional array called 'init_weight'. The previous values are stored in a history file and are pushed onto the top of a data structure called 'history_info' so as to provide an historical record of a finite period of time, as for example five minutes (See Appendix 1: ASSESS.C and ASSESS.H).

Detecting Purposeful Motion

The information stored in the history file is next analyzed by the function 'adjw_purposeful motion' (Refer to FIG. **26**; Appendix 1: SUPPORT.C) for signs of purposeful motion, and the weights for affected sensors adjusted accordingly and stored in an intermediate data structure called 'inter_weights'. This is accomplished as follows:

1. The algorithm identifies the first active sensor of a given group (i.e., sonar, infrared, microwave, etc.).
2. Data stored in the history file is examined to determine if adjacent sensors of the same group on either side of the active sensor had previously been active within some prespecified period of time.
3. If history of such activity is present, the weight of the active sensor is increased by an increment equal to its initial weight times some scaler **S1**.
4. In the event an adjacent sensor is found to have been active, the history file is again examined to see if the next sensor in the array also had previously detected motion.
5. If previous motion is again indicated, the weight of the active sensor is further increased by a second increment equal to its initial weight times some scaler **S2**.
6. This process is then repeated for all other active sensors of the given type, after which the remaining groups of motion detection sensors are similarly examined in kind.

In this fashion, if a temporal history of lateral motion across the field of view of the sensor array is present, such that adjacent sensors are activated in a distinct sequence, the resulting signature is classified as purposeful as opposed to random motion, and the active sensor weight is significantly increased.

Most of the motion detector arrays (microwave, passive infrared, acoustical, optical) are capable of angular resolution only, and provide no range information. An exception is the ultrasonic motion detection system **19*f*** (Refer to FIG. **5**) which identifies a potential intrusion through changes in measured target distances as seen by one or more sensors **536*i*** in the 24-element arrays **536*b*** and **536*c***. This feature provides an additional level of analysis performed on sonar data accumulated in the history file, in that purposeful motion of an intruder should result in a somewhat continuous path target profile, with no significant discontinuities, or jumps in target position.

Cross Correlation

The next step in the local security assessment routine is referred to as "cross correlation" (See Appendix 1: SUPPORT.C). This involves checking for correlation among the different sensor groups (i.e., infrared, ultrasonic, optical, etc.) to minimize nuisance alarms. The function 'adjw_angular_sensor fusion' (Refer to FIG. **28**) will increase the weight assigned to the output of a particular sensor if another type of sensor also detects motion along the same bearing, plus or minus some specified tolerance. This is accomplished as follows:

1. The first active sensor of a given group is identified.
2 The current value of the sensor weight is incremented by the scaled weight of any confirming sensors of other types which view the same or immediately adjacent areas, and stored again in 'current_weight', where:

$$\begin{matrix}\text{New}\\\text{Sensor}\\\text{Weight}\end{matrix} = \begin{matrix}\text{Old}\\\text{Sensor}\\\text{Weight}\end{matrix} + k_1\begin{pmatrix}\text{same}\\\text{zone}\\\text{factor}\end{pmatrix} + k_2\begin{pmatrix}\text{adjacent}\\\text{zone}\\\text{factor}\end{pmatrix}$$

3. The adjusted weight values (from 'inter.weight') of the confirming sensors are used for this calculation, as opposed to the initial weights (from 'init.-weight').
4. In this fashion, the increase in weighting is proportional to the confidence factor of the confirming sensor.

5. This process is then repeated for all other active sensors of the given type, after which the remaining types are similarly examined.

Composite Threat Calculation

Once the various weight contributions have been generated for the individual sensors of each type, the function 'calc_threat' is called to sum the weighted scores to generate a composite threat assessment for each of the 24 zones shown in FIG. **25**. For each zone, there exists a predetermined alarm threshold value, and any zone wherein the composite threat exceeds this threshold is assumed to be in an alarmed condition. The video camera **12**g_1 will be energized by local processor **402** when the composite threat for any given zone exceeds some scalar (typically 0.6) of the zone alarm threshold. The axis of the most active zone is used to graphically plot a threat vector on a map display of the secured environment, presented on video display **15** (FIG. **31**). Head positioning servo **19**j (FIG. **4**) then is commanded to position video camera **12**g_1 so that its optical axis is coincident with the orientation (bearing) of this threat vector. Software for directing the head positioning servo **19**j is set forth, by way of example, in Appendix 3. Head positioning servo (panning) systems such as employed in the present invention are well known, commercially available units. Software for implementing the display feature is provided by way of example, in Appendix 1 as INTRUDER.C and INDISP.C. In the event more than one zone is active, the three zones with the highest composite threat scores will generate threat vectors colored red, yellow, and white, in decreasing order of perceived threat severity. Video camera **12**g_1, if energized, will always be oriented towards the direction corresponding to the zone having the highest composite threat score, unless manually overridden by a human operator.

Global Security Assessment

The Global Security Assessment Software addresses two fundamental issues: (1) inhibiting those fixed installation sensors which are momentarily activated by the robot's passage through the protected area, and (2) fusing the alarm status data from the fixed installation sensors with the data from the mobile sensors mounted on robot **18** (or robots) in order to create a composite representation of the perceived threat. Flowcharts for software that would be implemented in host computer **14** for performing these functions are provided by way of example, in FIGS. **24–29** and **32–36**.

When robot **18** is moving in an area protected by fixed installation sensors, the security assessment system determines when the robot is about to enter or leave the coverage area of any given sensor. The sensor in question must be inhibited for that portion of the time when robot **18** is moving through its field of view, so that the motion of robot **18** does not generate a nuisance alarm. Once the robot has departed the coverage area, that particular sensor must be re-enabled. The robot's X-Y position is used to obtain the identification of all fixed sensors from the fixed sensor coverage layer that could be affected by the robot's motion at that particular instant. These sensors are then gated out when constructing the fixed-mobile correlation factor which is used to calculate the global composite threat. Of course, the robot's mobile coverage layer is time variant while mobile robot **18** is in motion.

The preferred embodiment uses a bit-map approach which determines if any point in the fixed sensor coverage layer lying within in a small area of ambiguity around robot **18** has the appropriate bit set for that particular sensor. Referring to FIGS. **32** and **34**, at the beginning of each inhibition loop, the Security Assessment Software must mark all the sensors as uninhibited, then inhibit only those affected by the robot so that when a robot leaves the coverage area, the associated sensor will be enabled once again.

An alternative to the bit-map method is to examine each sensor coverage polygon to see if the robot is within that polygon, then inhibit those sensors affected by the robot's presence. The polygons would be predefined by the operator using the MAPEDIT.C software presented in Appendix 1. The robot is modeled as a point. Consequently, representations of the fixed sensor coverage areas would be expanded by half the maximum dimension of the robot footprint. To determine if the robot is causing a fixed sensor to trip, the position of the robot would be used as an index into the coverage layer. The value of that location in the coverage layer then would determine which fixed sensors would be affected by the robot's presence.

Another alternative to the bit-map approach could be used if robot **18** is modeled as a simple convex polygon (e.g., a rectangle). The Sutherland and Hodgman polygon clipping algorithm can be used to determine whether or not robot **18** is completely outside or partially or completely inside the defined region. [See Sutherland, Ivan, E. and Hodgman, Gary W., "Reentrant Polygon Clipping," *CACM*, Vol. 17, pp. 32–42, 1974]. This particular technique clips a concave or convex polygon (sensor coverage polygon in this case) to an arbitrary convex polygon (robot). Each sensor area affected by the presence of the robot would be inhibited, and those not affected would be enabled. If both the coverage and robot polygons are convex, then the Cyrus and Beck algorithm can be used. [See Cyrus, M. and Beck, J., "Generalized Two- and Three-Dimensional Clipping," *Computers & Graphics*, Vol. 3, pp. 23–28, 1978].

In the preferred embodiment, once the fixed sensors affected by the robot have been inhibited, it is necessary to correlate data provided by all of the fixed sensors with each other, as well as with the outputs of mobile sensors on the robot. All sensors are modeled with bit-maps [Refer to FIGS. **35A** and **35B**}. Data corresponding to outputs of the sensors are integrated with the other maps to form the fixed-mobile correlation factor.

An alternative method of correlating the data may be employed if all the sensors are modeled solely with polygons. Then it would be necessary to determine the specific polygon that is the largest subset of all the active polygons. Another alternative for performing data correlation employs a hybrid scheme. In this scheme, a hit bit-map can be created based on how many polygons cover each cell in the map. Regardless of the method used, it is first necessary to rotate the robot's coordinate system to correspond with that of the fixed sensors.

When the robot is stationary, the data fusion software determines the degree of interaction of the outputs corresponding to sensors on the robot with those of the fixed sensors in the "hit" area in order to develop a composite threat weight. Accordingly, the system first determines the fixed sensors which are active and their

associated coverage areas, as stored in the fixed coverage layer. This information then is logically combined with information provided from the calculated coverage areas, in absolute coordinates, of the active robot sensors. The result is stored as the fixed-mobile correlation factor, which is then used to calculate the global composite threat. The fixed-mobile correlation factor represents the maximum fixed intrusion detector threat score corresponding to the fixed intrusion detectors that detect a potential intrusion. The manner in which this calculation is accomplished is discussed in the following paragraphs.

To initially set the appropriate bits in the fixed sensor coverage layer, the coverage extents are defined using the Map Editor (Appendix 1: MAPEDIT.C). A standard polygon scan conversion algorithm [See Rogers, David F., *Procedural Elements For Computer Graphics*, McGraw-Hill Book Company, New York, 1985] sets the correct bit for that particular sensor upon program start-up, where an assigned bit corresponds to each fixed sensor [Refer to FIG. 32 and Appendix 1: FIXEDSEN.C].

The mobile sensor coverage layer associated with the robot is created when needed to fuse data between the sensors of fixed sensor system **12** and sensor system **19** on robot **18**. The information on robot heading and X-Y position is first obtained from local processor **402**, and then the mobile array values are generated according to preestablished rules described below. By way of example, the preferred embodiment employed a 8-bit representation. The position and orientation of the robot is "frozen" before calculating the array values. Again, a standard polygon scan conversion algorithm (implemented by POLYFILL.C, set forth in Appendix 1; See also Rogers, David F., *Procedural Elements For Computer Graphics*, McGraw-Hill Book Company, New York, 1985) is used to set the appropriate bits for the X-Y locations in the array up to the imposed extents, which are defined below.

For example, the range of microwave motion detector system **19*d*** may be constrained by the room boundaries, as might be vibration sensor **19*b***. Ultrasonic motion detector system **19*d*** may be constrained to where all bits are set within a circle of ambiguity of some pre-specified diameter, centered at the reported range value of the disturbance along the appropriate bearing. The limits on an acoustical coverage area could be defined as a wedge of some specified angle of uncertainty along the calculated bearing line, out to a distance constrained by the room or map boundary.

When a global correlation (correlating the outputs of both triggered fixed and mobile sensors) is desired in a static scenario, host computer **14** sets all the appropriate bits in the mobile layer for sensor system **19** according to the robot's current position and heading. [Refer to FIG. **35A**]. In essence, this effects a coordinate transform which makes the mobile sensors look like fixed sensors for that instant in time. Then, host computer **14** determines which sensors are alarmed, and begins to generate the fixed-mobile correlation factor using the sensor coverage information encoded in the fixed and mobile sensor layers. The fixed-mobile correlation factor is used as one of the components in calculating the global composite threat.

An alternative method of correlating the outputs of both triggered fixed and mobile sensors is to find the largest polygon completely contained within all the other active polygons, i.e. find the largest subset that is a subset of all other subsets. This is most easily accomplished using the following steps: Pick an initial polygon (any one will do). Pick another polygon that has not been clipped. Clip the two polygons against each other, resulting in a third representing the intersection. Using the resulting polygon as the initial polygon, repeat the process until all polygons have been clipped. The output is the maximum size polygon contained within all the other polygons. If all polygons are guaranteed to be convex, then the Cyrus and Beck clipping algorithm can be used. Otherwise, each convex polygon must first be decomposed into two or more convex polygons, then clipped. Alternatively, a more general algorithm capable of clipping a concave polygon against another concave polygon could be used. [See Weiler, Kevin, and Atherton, Peter, "Hidden Surface Removal Using Polygon Area Sorting," *Computer Graphics*, Vol, 11, pp. 214–222, (Proc. SIGGRAPH 77), 1977].

OPERATION OF THE INVENTION

As an example operational scenario, mobile robot **18** is assigned a patrol route (or a discrete location) by the operator. The path planner calculates an appropriate path, whereby mobile robot **18** assumes its first assigned surveillance position. All primary detection sensors are online (optical, acoustical, infrared, vibration, and microwave) and RF data link **20** is in standby operational status. Video camera **12*g*$_1$** and associated RF video link **20*b*$_2$** are deactivated.

If a possible disturbance is detected by one of the fixed installation motion detectors of fixed sensor system **12**, an appropriate signal is provided via AIU **16** to host computer **14**. The human operator is alerted by an audio beep from alarm system **22**. In one type of scenario, host computer **14** may determine that the triggered sensor could not have been set off due to the motion of mobile robot **18** by noting that the current dead-reckoned position of the robot is not within the designated coverage area of the alarmed sensor. The Path Planner Software then dispatches robot **18** to a location where mobile sensor system **19** can observe the area in question. With no additional confirmation from mobile security sensor system **19**, the Realtime Assessment Software, after a designated period of time, classifies the threat as a nuisance alarm. All fixed and mobile sensor reports are continuously time stamped and logged to disk in host computer **14** for later replay and analysis. The robot then continues its assigned patrols.

In another example of a typical operational scenario, a second disturbance is later detected by another sensor of fixed security sensor system **12**. The robot is dispatched to the area and assesses the situation. In this example, however, the primary mobile detection sensors also react in confirmation. The threat level is sufficient for the software to activate secondary sensors, and the ultrasonic motion detection system **19*f*** is enabled. Cross correlation between sensors shows a strong likelihood of an intruder at position (X,Y) on the map of the secure area, as indicated in the lower half of control screen **890** (FIG. **31**) of video display **15**. The software which assembles this data and presents it on control screen **890** is provided, by way of example, in Appendix 1 as MAP.C, INDISP.C and INTRUDER.C.

The Realtime Assessment Software activates video camera **19*h*** onboard the robot. The camera is automatically positioned along the bearing of the disturbance by head positioning servo **19*j***. The human operator is noti-

fied by a second audible alert, while video motion detector system **12g** surveys the scene under surveillance. If the motion detected by video camera $\mathbf{12}g_1$ confirmed as an actual intrusion, alarm system **22** provides an audible output. The human operator is able to observe the intruder on video monitor **28**, and may optionally see the (X,Y) position of the intruder depicted in a floor plan map, displayed on video display **15** by host computer **14**.

Once the relative bearing to an intruder has been established, the bearing can be used to calculate a motion command which causes mobile robot **18** to rotate in place until the intruder is directly ahead of the robot, centered on the axis of the collision avoidance system **450**. Range information gathered by collision avoidance system **450**, normally used to avoid an object in the path of the robot, provides information used to direct the robot towards the intruder and to follow him. The robot's mean forward velocity is adjusted as a function of range to the intruder, and a calculated differential in left and right drive motor speeds is introduced as a function of how far off centerline the target appears. This differential causes the robot to turn towards the target being followed in a controlled fashion, until it appears centered, all the while maintaining a specified distance interval. The robot's absolute X-Y position is graphically displayed on a map of the secured area, while camera transmits live video to display **890** for evaluation by the operator.

Unless otherwise indicated all software is implemented in host computer **14**. Program listings set forth in Appendix **1** are written in "C" and are provided by way of example only. Program listings set forth in Appendices 2 and 3 are written in **6502** assembly language and are provided by way of example only. The software listed in Appendix 2 is implemented in local processor **402**. The software listed in Appendix 3 is implemented in the processor of video motion detector system $\mathbf{12}g_1$. The scope of the invention includes all modifications to such software as would be evident in light of the appended teachings. Furthermore, the scope of the invention includes software written in languages other than those set forth herein.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. For example, the scope of the invention includes the employment of one or more mobile robots **18** to patrol the secured environment. Therefore, singular references to mobile robot **18** are to be understood as referring to one or more mobile robots **18**. Therefore, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

```
**************************************************
*  DATA FUSION METHOD AND SYSTEM FOR A FIXED     *
*    AND MOBILE SECURITY SENSOR SYSTEM            *
*                                                *
*              NAVY CASE NO. 72775                *
*                                                *
*      INVENTORS:  HOBART R. EVERETT             *
*                  GARY A. GILBREATH             *
*                                                *
*              A P P E N D I X  1                 *
**************************************************
```

APPENDIX 1
SOFTWARE LISTINGS
LANGUAGE: "C"

ANIMATE.C	LISTS.C	SYSCALL.H
ASSESS.C	LOGGER.C	SYSDEFS.H
ASSESS.H	MAKEMAP.C	TELE.C
ASYNCH.C	MAP.C	TIMESTMP.C
ASYNCH.H	MAPCUR.C	TIMESTMP.H
BAUDRATE.C	MAPDEFS.H	TTY.C
BAUDRATE.H	MAPEDIT.C	VOX1.H
BB-EDIT.C	MINTURNS.C	VOX2.H
BB-EDIT.H	MISC.C	VOX3.H
CA.C	MYTYPES.H	VOX4.H
CELLIST.C	OA.C	ZOOM.C
DEADRECK.C	PACKET.H	
DISPLIST.C	PATHPLAN.C	
DISPLIST.H	PE.C	
EXECUTE.C	POLYFILL.C	
FILL1.C	PROTOS.H	
FIXED.C	QUEUE.H	
FIXEDSEN.C	RECAL.C	
FUNCKEYS.C	ROBART.C	
FUNCKEYS.H	ROBICONS.H	
GLOBAL.C	RTCLK.H	
IBMIO.C	SCRIPT.C	
IBMIO.H	SENSOR.C	
IBMIO.C	SENSOR.H	
IBMRTCLK.C	SERIAL.H	
INDISP.C	SETUP.C	
INTRUDER.C	SIO.C	
K2A.H	SONPLOT.C	
LINESTUF.C	SPEECH.C	
LINESTUF.H	SQRT.C	
LINKDEFS.H	SUPPORT.C	
LINKRBRT.C	SUPPORT.H	

We claim:

1. A system for detecting intrusion in a secured environment, comprising:

a first sensor fixedly positioned and operably disposed to provide a first output signal corresponding to detection of a first perturbation in said environment;

a mobile platform operably disposed to be directed to travel along a path through said environment in response to receiving path control output signals;

a second sensor mounted to said mobile platform and operably disposed to provide a second output signal corresponding to detection of a second perturbation in said environment;

a digital data processor, communicatively coupled to receive said first output signal from said first sensor and to receive said second output signal from said second sensor, for assigning weighting coefficients to representations of each of said first and second output signals to generate weighted first and second values, for determining a sum of said weighted first and second values, for providing an intrusion alert output signal when said sum exceeds a reference value, and for providing said path control output signals to said mobile platform, to direct said mobile platform to a particular location in said environment;

an alarm system for generating an intrusion alert in response to receiving said intrusion alert output signal from said digital data processor.

2. The system of claim 1 in which said first sensor is inhibited by said digital data processor when said mobile platform is in a zone of coverage of said first sensor and said first sensor is enabled by said digital data processor when said mobile platform is outside said coverage zone.

3. The system of claim 2 further including a data link communicatively coupled between said digital data processor and said mobile platform for conveying said path control output signals from said digital data processor to said mobile platform and for conveying said second output signal from said second sensor to said digital data processor.

4. The system of claim 3 wherein:

said mobile platform further includes a collision avoidance system which generates a third output signal which is provided to said digital data processor for indicating the presence of any obstacles that may obstruct said path of said mobile platform; and

said digital data processor directs said mobile platform to travel a modified path to said particular location in said environment which avoids said obstacles.

5. The system of claim 4 wherein said second sensor is an acoustical sensor.

6. The system of claim 4 wherein said second sensor is a vibration sensor.

7. The system of claim 4 wherein said second sensor is an infrared motion sensor.

8. The system of claim 4 wherein said second sensor is a microwave motion sensor.

9. The system of claim 4 wherein said second sensor is an ultrasonic motion detector.

10. The system of claim 4 wherein said second sensor is an optical motion detector.

11. The system of claim 4 further including:

a head positioning servo mounted to said mobile platform and operably disposed to receive pan control output signals generated by said digital data processor through said data link; and

a video surveillance camera mounted to said head positioning servo so that said video surveillance camera may be oriented to detect a video scene of a location at which said first or second perturbations were detected.

* * * * *

US005818733A

United States Patent [19]
Hyuga

[11] **Patent Number: 5,818,733**
[45] **Date of Patent: Oct. 6, 1998**

[54] **COMMUNICATION METHOD AND SYSTEM FOR SAME**

[76] Inventor: **Makoto Hyuga**, 25-58, Misumi-cho 2-chome, Higashimurayama-shi, Tokyo 189, Japan

[21] Appl. No.: **454,285**
[22] PCT Filed: **Jul. 1, 1994**
[86] PCT No.: **PCT/JP94/01074**
§ 371 Date: **Jun. 16, 1996**
§ 102(e) Date: **Jun. 16, 1996**
[87] PCT Pub. No.: **WO96/01539**
PCT Pub. Date: **Jan. 18, 1996**
[51] **Int. Cl.**[6] **G06F 17/00**
[52] **U.S. Cl.** **364/550**
[58] **Field of Search** .... 364/514 R, 705.07, 364/550; 340/825.45, 825.19, 825.36, 531, 536, 574; 348/77, 159

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Primary Examiner—Ellis B. Ramirez
Attorney, Agent, or Firm—Morrison Law Firm

[57] **ABSTRACT**

When emergency button (**11**) of mobile unit (**1**) of a person who has suddenly fallen ill or other emergency, locational signals representing its own location and ID data are transmitted to receiver (**21**) of management unit (**2**) installed in the caddie master's office or at other locations. Based on the locational signals from receiver (**21**), camera controller component (**26**) selects camera (27_1)~(27_n), (27_c) and controls panning and tilting of the selected camera, thereby adjusting its angle. Signals representing pictures taken by camera (27_1)~(27_n), (27_c) are received by visual image receiver component (**28**) and, together with vocal signals received from voice communication device (**16**) through voice communication device (**24**), transmitted from relay device (**25**) through a public circuit to visual image receiver component (**32**) and voice communication device (**31**) of remote unit (**3**). By operating the dial or push buttons of voice communication device (**31**), panning and tilting of camera (27_1)~(27_n), (27_c) are controlled in order to adjust its angle, and vocal signals are transmitted from voice communication device (**31**) to mobile unit (**1**).

15 Claims, 10 Drawing Sheets

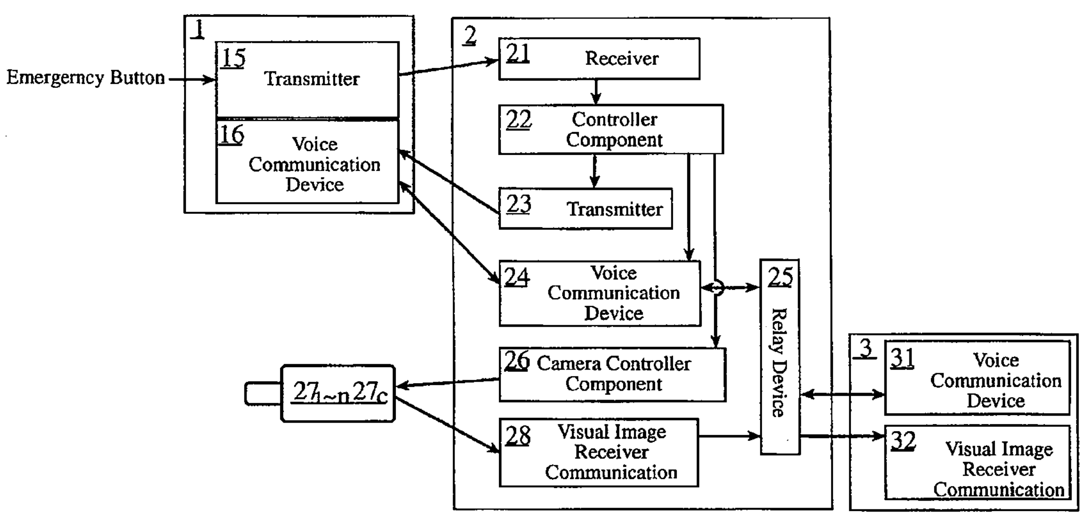


Fig. 1

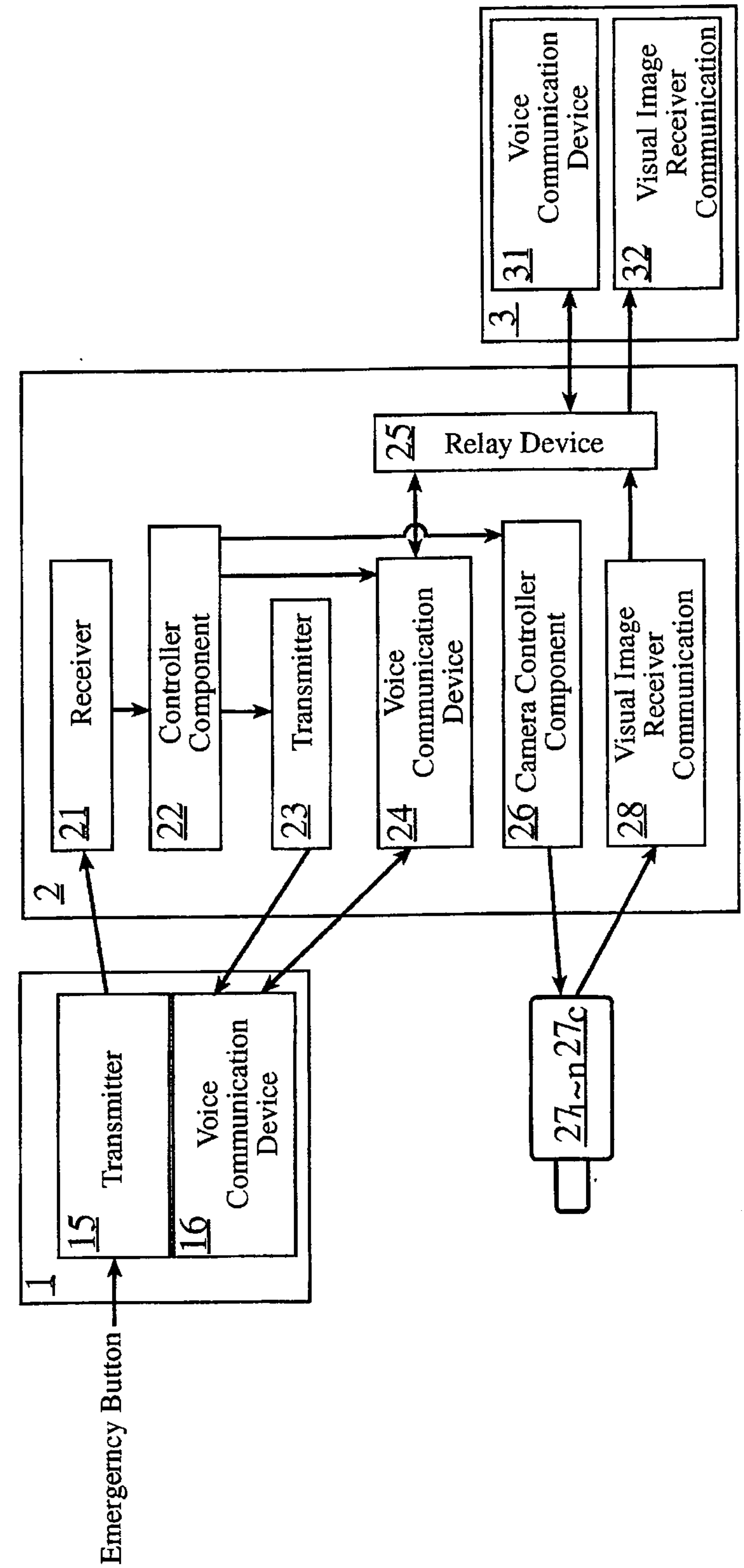

Emergency Button
1
15 Transmitter
16 Voice Communication Device
2
21 Receiver
22 Controller Component
23 Transmitter
24 Voice Communication Device
25 Relay Device
26 Camera Controller Component
28 Visual Image Receiver Communication
27a~n 27c
3
31 Voice Communication Device
32 Visual Image Receiver Communication

Fig. 2

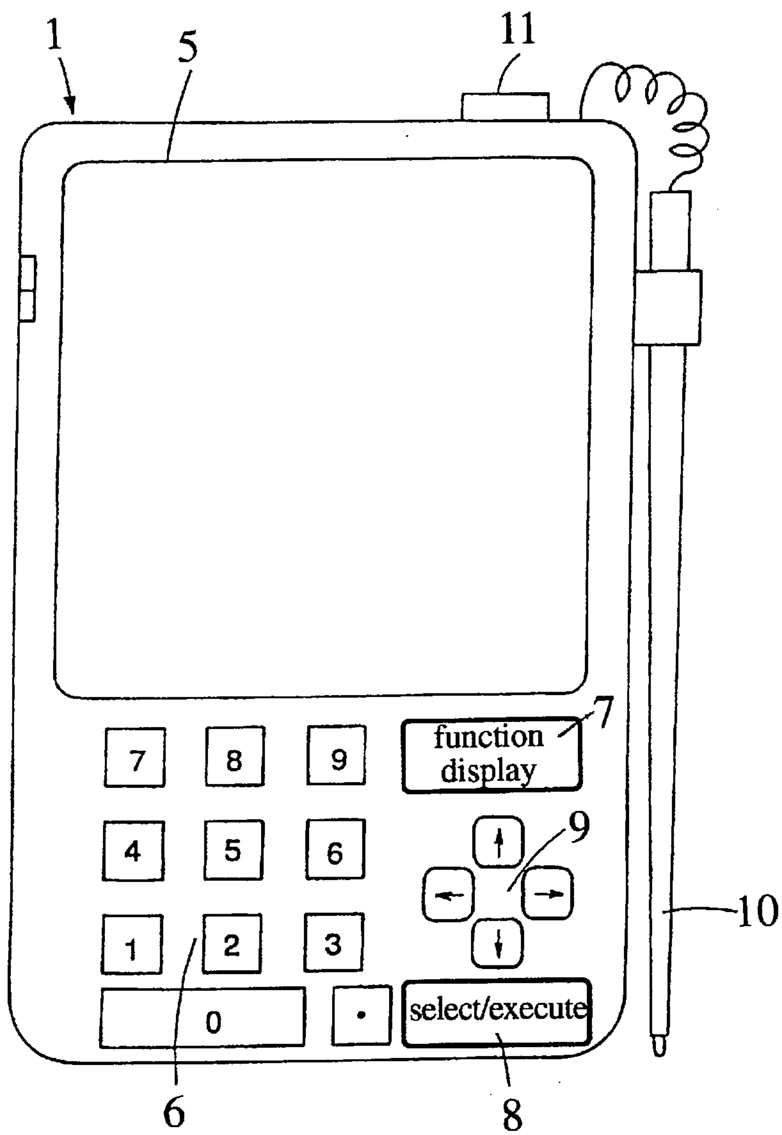


Fig.3

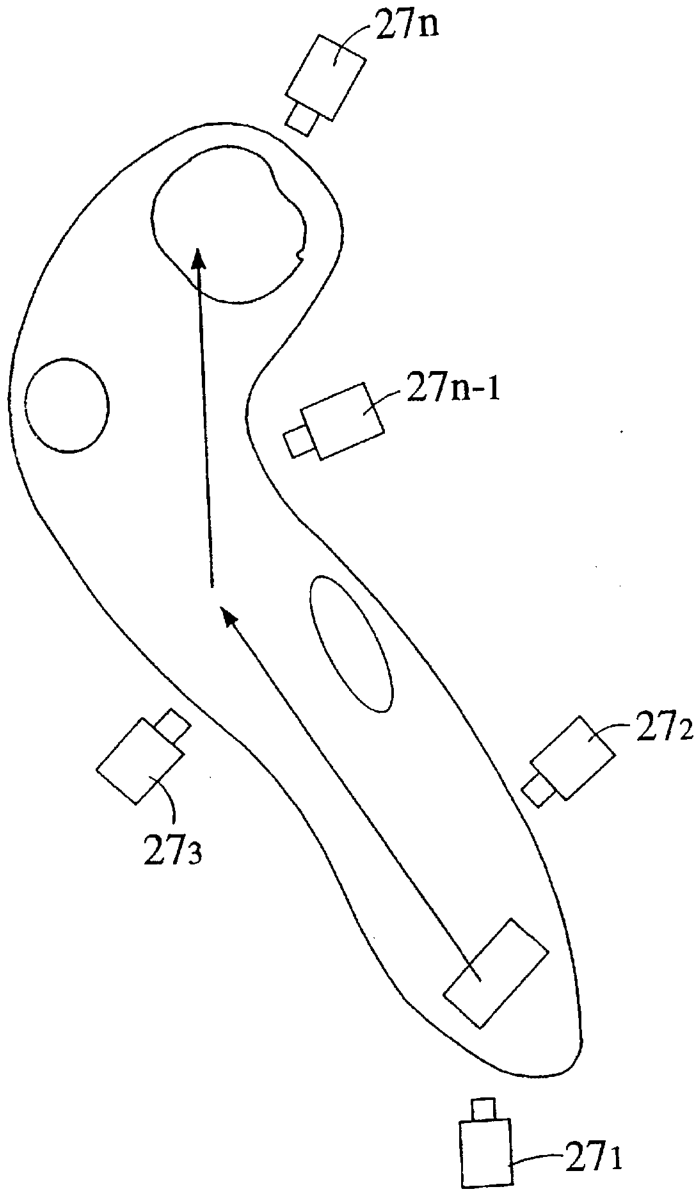


Fig. 4

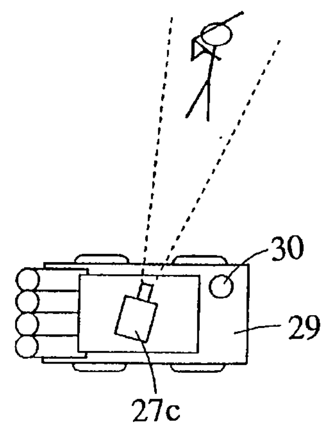

30
29
27c

Fig. 5

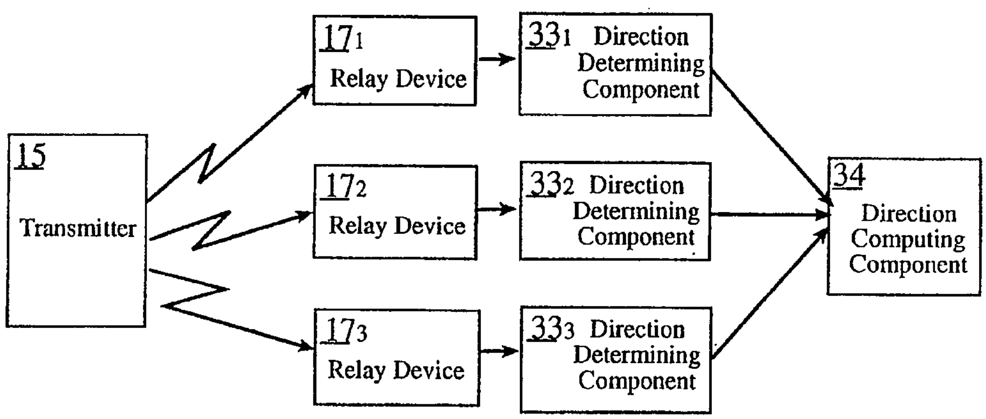

15
Transmitter
17_1 Relay Device
17_2 Relay Device
17_3 Relay Device
33_1 Direction Determining Component
33_2 Direction Determining Component
33_3 Direction Determining Component
34 Direction Computing Component

Fig. 6

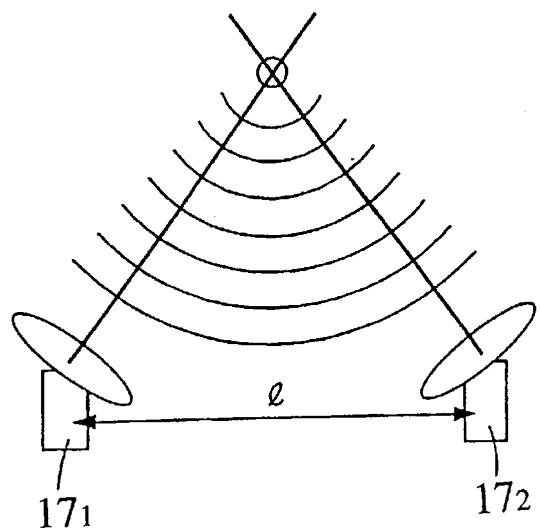


Fig. 7

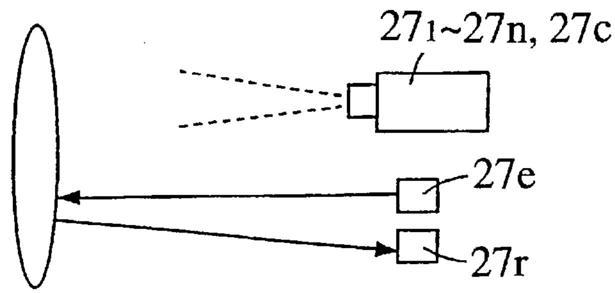


Fig. 8

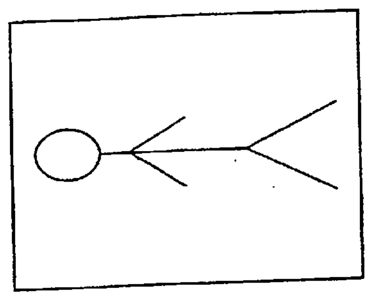


Fig. 9

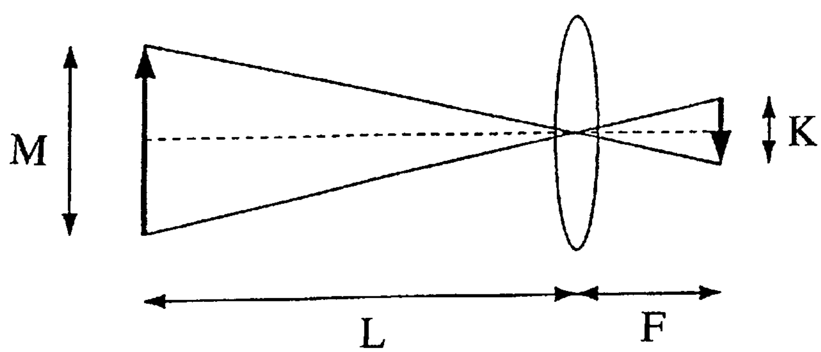


Fig. 10

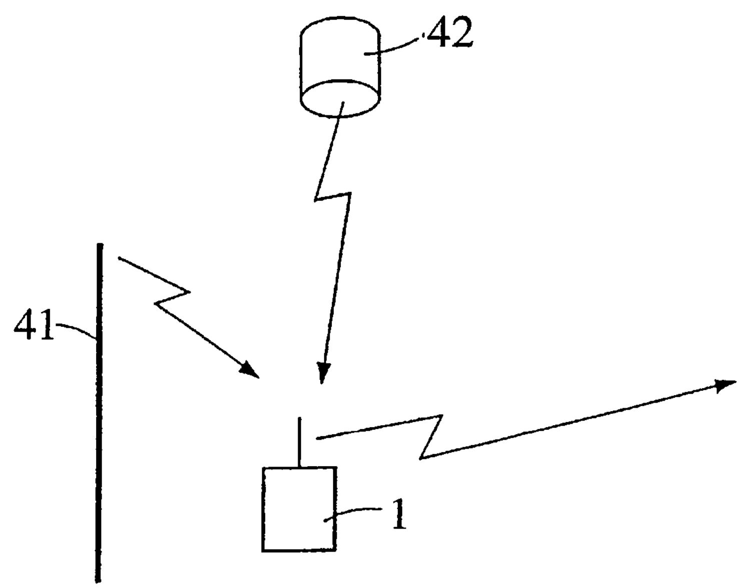


Fig. 11

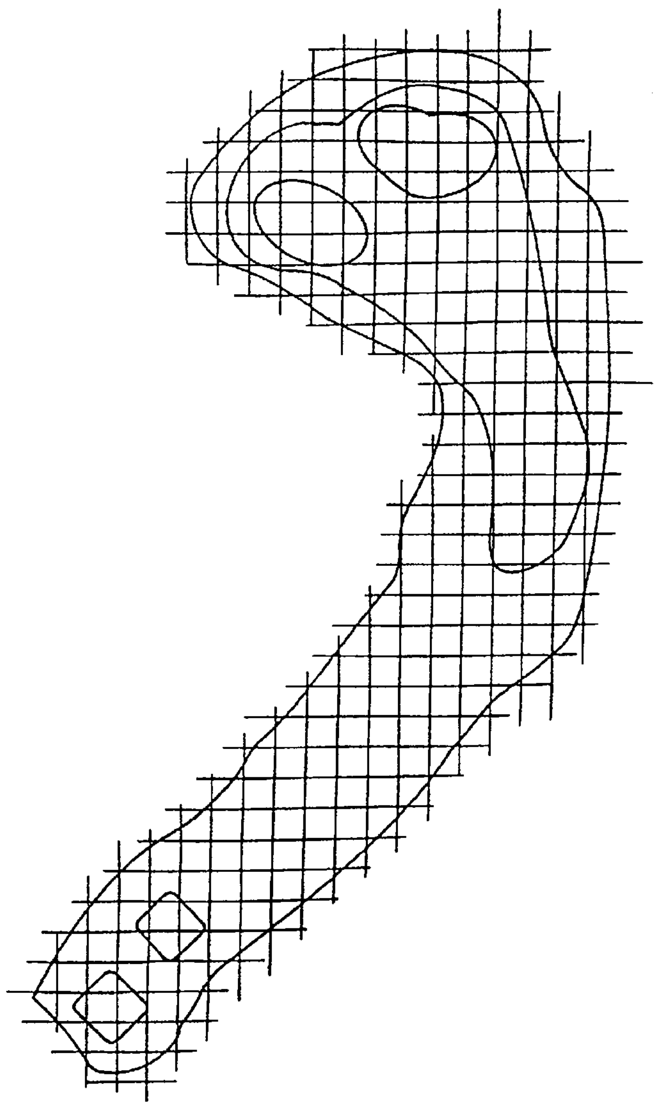


Fig. 12

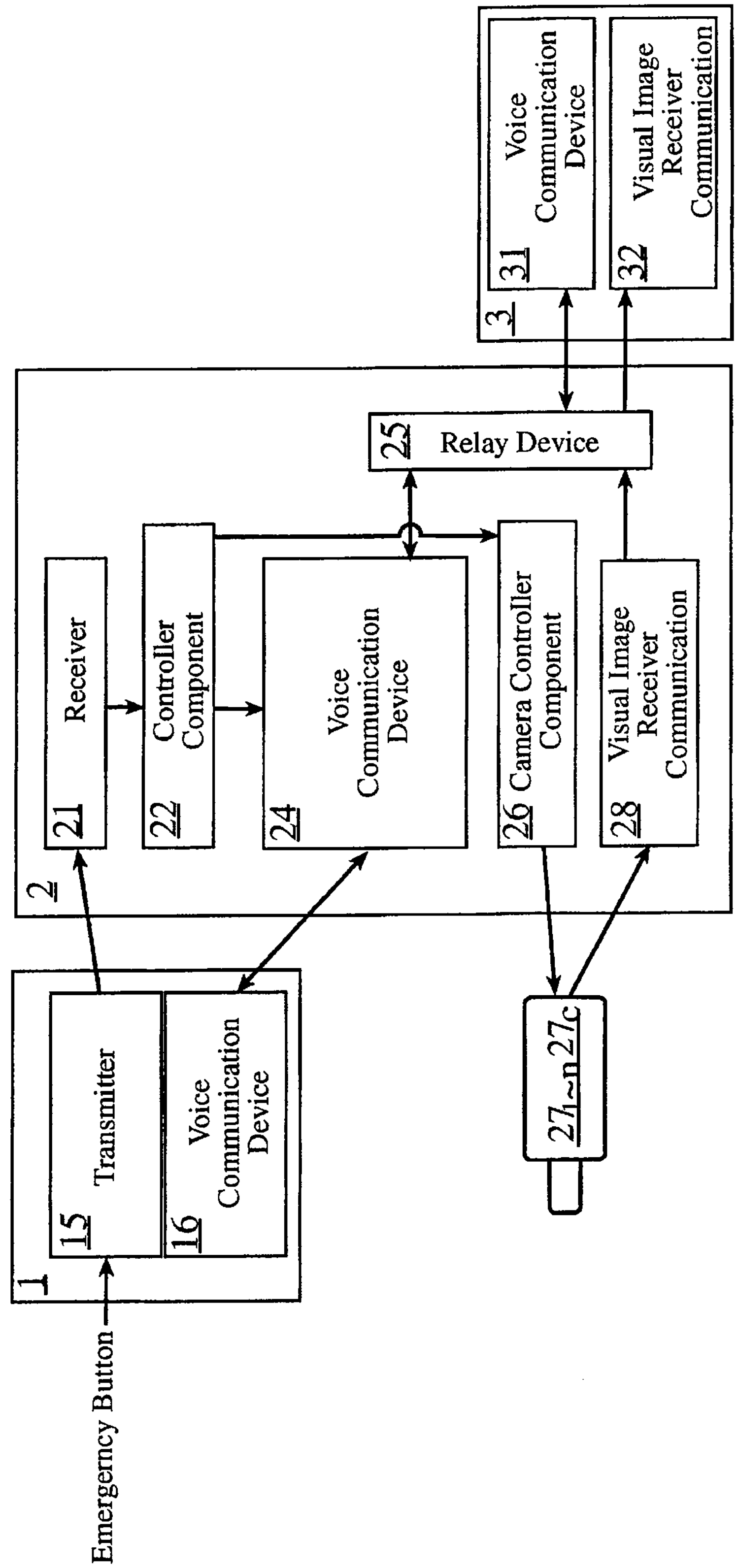
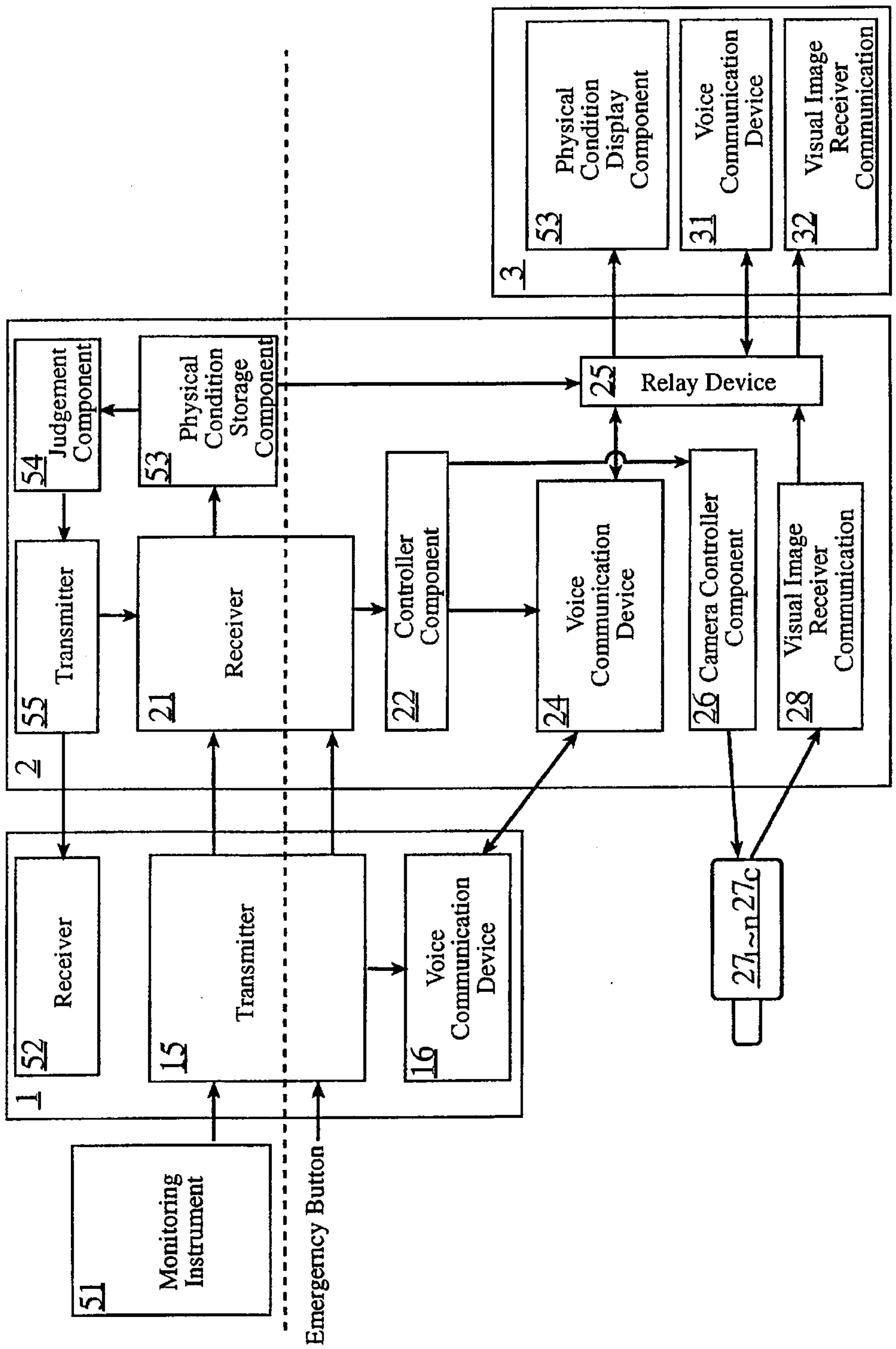

Emergency Button
1
15 Transmitter
16 Voice Communication Device
2
21 Receiver
22 Controller Component
24 Voice Communication Device
25 Relay Device
26 Camera Controller Component
28 Visual Image Receiver Communication
27_1~n27c
3
31 Voice Communication Device
32 Visual Image Receiver Communication

Fig. 13


1
52 Receiver
15 Transmitter
16 Voice Communication Device
51 Monitoring Instrument
Emergency Button
2
55 Transmitter
54 Judgement Component
21 Receiver
53 Physical Condition Storage Component
22 Controller Component
24 Voice Communication Device
25 Relay Device
26 Camera Controller Component
28 Visual Image Receiver Communication
27₁~n27c
3
53 Physical Condition Display Component
31 Voice Communication Device
32 Visual Image Receiver Communication

COMMUNICATION METHOD AND SYSTEM FOR SAME

BACKGROUND OF THE INVENTION

This invention relates to a method and system for communication of data including visual images taken by an imaging device.

Conventionally, various systems for remotely controlling an imaging device in its focusing and imaging functions such as panning and tilting, and transmitting pictures obtained by said remote control through a communication means are widely known.

Also known to those skilled in the art are a system disclosed in Japanese Patent Laying-open No. 191133/1988 which calls for transmitting signals from a transmitting means attached to a subject to be photographed and taking photographs of this subject upon receiving these signals using a receiving means; another disclosed in Japanese Utility Model Laying-open No. 117625/1989 which calls for taking visual images of a subject by means of receiving signals transmitted from a transmitting means attached to the subject and causing an imaging device to follow the direction of the strongest signal, and another disclosed in Japanese Patent Laying-open No. 134351/1981 which calls for following a subject using a transmitting means attached to the subject and, shooting for a specified period of time.

However, the aforementioned system which controls performance of an imaging device by remote control is capable of receiving visual data signals only by manually changing the settings of the imaging device, and the configurations according to Japanese Patent Laying-open No. 191133/1988 and Japanese Utility Model Laying-open No. 117625/1989 merely call for causing an imaging device to follow a subject to take visual images thereof. Therefore, none is capable of fully utilizing the pictures taken.

Further, in case of an emergency, for example, if conditions of a patient or his situation can be visually presented, it would help a doctor, who may be at a hospital or another remotely located facility in making an appropriate decision that might save the patient's life. For such a reason, there exists a need for a system which is capable of easily transmitting visual images of a specific subject to the doctor in such a case as above.

OBJECTS AND SUMMARY OF THE INVENTION

In order to solve the problems in the prior art, an object of the invention is to provide a communication method and system for transmitting visual images which have been taken by an imaging device and sent by a sender to the receiving party through a relay station.

A method according to the invention calls for transmitting signals representing the voice of a sender; receiving the vocal signals from the sender at a relay station; controlling imaging functions of an imaging device to take pictures of the sender; transmitting the vocal signals from the sender together with the visual images of same, which have been taken by the imaging device, from the relay station to a receiving party; and transmitting vocal signals of the receiving party through the relay station to the sender. Therefore, as the invention is capable of transmitting visual images of the sender to the receiving party through the relay station and allowing 2-way voice communications between the sender and the receiving party through the relay station, the receiving party is able to easily obtain visual images of the sender, and both parties can easily communicate with each other.

According to another feature thereof, the invention calls for transmitting data for the location of the sender so that the locational data is received and used to control the performance of the imaging device. Therefore, according to the invention, it is easy to know the location of the sender of the signals and take his picture with an imaging device.

According to yet another feature of the invention, the receiving party controls the direction in which the imaging device is pointed. Therefore, it is easy for the receiving party to obtain desired pictures.

According to yet another feature of the invention, physical conditions of a subject are monitored; and the relay station transmits the data of his physical conditions to the receiving party together with his pictures taken by the imaging device. With the configuration as above, the receiving party is able to easily obtain data of physical conditions of the subject and, therefore, is ensured of knowing the subject's conditions with visual images of same.

According to yet another feature thereof, the invention calls for storing data of normal conditions of a subject; and transmitting the normal condition data together with the aforementioned data of his physical conditions to the receiving party. With the configuration as above, the receiving party is able to assess the physical conditions of the subject referring to his normal conditions, thereby more reliably judging his current condition.

Furthermore, according to yet another feature of the invention, the invention is provided with one or more mobile units, each of which has a mobile unit transmitting/receiving means for transmitting and receiving vocal signals; a remote unit which has a remote unit transmitting/receiving means for transmitting and receiving vocal signals as well as receiving visual signals, the remote unit also having an image display means for displaying visual images; one or more imaging devices; and a management unit which has an imaging device controlling means for controlling the imaging function of the picture-taking devices, and a relay means for relaying communication between the aforementioned mobile unit transmitting/receiving means and remote unit transmitting/receiving means. With the configuration as above, the remote is capable of receiving signals representing visual images of a subject taken by imaging devices, and voice communication is possible between the remote unit and the mobile unit.

According to yet another feature of the invention, the remote unit is provided with picture-taking directing means for directing the manner of performance of the imaging devices. With the configuration as above, which permits the remote unit to easily direct how pictures of a subject are to be taken, it is easy for the user of the remote unit to obtain desired pictures.

According to yet another feature thereof, the invention is provided with a physical condition monitoring means for monitoring the physical condition of a subject; and the mobile unit transmitting/receiving means of each mobile unit is capable of transmitting the physical condition data through the relay station to the remote unit transmitting/receiving means. With the configuration as above, the user of the remote unit is able to easily obtain data concerning the physical condition of the subject and, therefore, is ensured of knowing the subject's condition with visual images of same.

According to yet another feature thereof, the invention is provided with a physical condition storage means for storing

data of normal condition of a subject; and a relay means to transmit the normal condition data together with the aforementioned data of his physical condition to the remote unit transmitting/receiving means. With the configuration as above, the user of the remote unit is able to assess the physical condition of the subject in the context of his normal condition, thereby more reliably judging his current condition.

According to yet another feature thereof, the invention is provided with an image composite means for combining visual images of a subject taken by an imaging device with data of his physical condition which has been monitored by the physical condition monitoring means. With the configuration as above, it is easy for the user of the remote unit to know the status of the subject and data of his physical condition by way of looking at the pictures.

According to yet another feature of the invention, each mobile unit is provided with an extracting means to extract data for its own location; the mobile unit transmitting/receiving means transmits the locational information extracted by the extracting means to the relay means; the management unit is provided with a receiving means to receive said locational information from the mobile unit; and the imaging device controlling means controls performance of the imaging devices based on the locational information received as above. With the configuration as above, it is easy to know the location of the sender and selectively control the appropriate imaging devices with the imaging device controlling means.

The above, and other objects, features and advantages of the present invention will become apparent from the following description read in conjunction with the accompanying drawings, in which like reference numerals designate the same elements.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a block diagram illustrating a communication system according to an embodiment of the present invention;

FIG. **2** is a front view of a mobile unit of a communication system according to an embodiment of the present invention;

FIG. **3** is an explanatory drawing of disposition of imaging device of a communication system according to an embodiment of the present invention;

FIG. **4** is an explanatory drawing to show how an imaging device placed on a cart, is used;

FIG. **5** is a block diagram illustrating the extraction of a location by means of a plurality of receiving devices of a communication system according to an embodiment of the present invention;

FIG. **6** is an explanatory drawing to further illustrate the principle triangulation range finding during the location extraction illustrated in FIG. **5**;

FIG. **7** is an explanatory drawing to illustrate range finding by an imaging device;

FIG. **8** is an explanatory drawing illustrating a properly framed subject;

FIG. **9** is an explanatory drawing to illustrate the relationship between the distance and zooming with said imaging device;

FIG. **10** is an explanatory drawing to illustrate the principle of location detection by means of GPS;

FIG. **11** is an explanatory drawing to illustrate a golf course divided into cells;

FIG. **12** is a block diagram illustrating a communication system according to another embodiment of the present invention; and

FIG. **13** is a block diagram illustrating a communication system according to yet another embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Next, a communication system according to an embodiment of the present invention is explained hereunder, referring to the drawings, where the communication system is utilized on a golf course.

Referring to FIG. **1**, numeral **1** denotes a mobile unit which is in the possession of each player or caddie. Each mobile unit **1** is capable of communicating through a wireless means, such as radio waves, with management unit **2**, which is installed in a clubhouse and serves as a relay station. Through ISDN or public lines, such as a general telephone line, or wireless means, management unit **2** is capable of communicating with a remote unit **3** installed in such facilities as a hospital.

As shown in FIG. **2**, mobile unit **1** is provided with a liquid crystal display **5** to display guidance and other information, a ten-key pad **6** to input scores and so forth, a function display key **7** to display various functions to be performed, a select/execute key **8** and scroll keys **9**, as well as a light pen **10** attached to the mobile unit and an emergency button **11** located on the topside of the unit. And as shown in FIG. **1**, mobile unit **1** is provided with a transmitter **15** and a voice communication device **16**. Transmitter **15**, provided with its own identification number, which may be, for example, the personal identification number of the player in possession of the mobile unit **1**, and transmits signals revealing its location together with its identification, and as appropriate, notification of an emergency. Mobile unit **1** is also provided with voice communication device **16** having voice communication capability. In addition to the above mentioned functions, mobile unit **1** is also capable of performing such functions as score tabulation, detecting its own location, guidance display, settling accounts and so forth.

Referring again to FIG. **1**, management unit **2** is provided with a receiver **21** which receives signals from transmitter **15** of mobile unit **1** either directly or by way of antennae disposed at appropriate locations, and a controller component **22** which executes control commands based on information received from receiver **21**. Further, controller component **22** is connected to transmitter **23** which activates voice communication device **16** of a mobile unit **1**. In addition, controller component **22** is provided with voice communication device **24** which allows voice communication with voice communication device **16** of mobile unit **1** to occur after voice communication device **16** is activated. Controller component **22** is also connected to a camera controller component **26**, which issues commands pertaining to the selection, direction, angle, and when the situation demands, the distance, of each respective imaging devices 27_1~27_n, 27_c. Further, signals representing visual images from any one of imaging devices 27_1~27_n, 27_c are received by visual image receiver component **28**, with visual image receiver component **28** and voice communication device **24** being connected to a relay device **25**.

Remote unit **3** is provided with a voice communication device **31**, which may be a telephone or the like, and a visual image receiver component **32** which may be a monitor.

Voice communication device **31** and visual image receiver component **32** are connected to relay device **25** of management unit **2** by such means as the aforementioned public transmission lines.

As shown in FIG. **3**, imaging devices 27_1 to 27_n are placed around the perimeter of each hole. Further, as shown in FIG. **4**, an on-vehicle imaging device 27_c may be placed atop a golf cart **29**, in which case on-vehicle receiver **30** which receives control signals from camera controller component **26** is also placed atop a golf cart **29**, imaging device 27_c being driven by on-vehicle receiver **30**. Each imaging device 27_1~27_n, 27_c is respectively provided with mechanisms to perform panning, tilting, as well as zooming, and may also be provided with auto-focus capability.

Selection of imaging devices 27_1~27_n, 27_c as well as control of panning, tilting and zooming of the selected imaging devices 27_i is performed by imaging device controller component **26**. However, on-vehicle camera 27_c need not be among any of said imaging devices 27_i. Further, in cases where imaging devices are to be automatically selected, an imaging device 27_1~27_n, 27_c nearest the subject to be imaged, for example, can be selected.

As shown in FIG. **5**, a plurality of relay devices 17_1~17_n and direction determining components 33_1~33_n may be provided, relay devices 17_1~17_n being respectively provided with directional antennae and corresponding to said direction determining components 33_1~33_n so that the location of transmitter **15** may be detected by a location computing component **34** based on the direction determined by these direction determining components 33_1~33_n. As to a number of relay devices 17_1~17_n, at least two devices are needed to determine a direction and a distance by using the principle of triangulation.

Next, referring to FIG. **10**, another embodiment of the present invention is explained hereunder, said embodiment calling for detecting a location by means of mobile unit **1** itself and transmitting signals including the data for the location thus detected.

In this case, the direction and distance to mobile unit **1** from any of imaging devices 27_1~27_n, 27_c can be determined by means of, for example, providing each hole with a plurality of antennae **41** which transmit reference radio waves; or as a second example providing mobile unit **1** with a navigation function such as GPS (Global Positioning System) which uses reference radio waves from a plurality of satellites **42**. In these examples, mobile unit **1** converts the vectorial information of its location relative to each of reference antennae **41** or satellites **42**, or a combination thereof, into location in terms of coordinates, such as latitude and longitude. Consequently, the direction and distance to mobile unit **1** from any one of imaging devices 27_1~27_n, 27_c can be computed from the absolute coordinate locations of mobile unit **1** and the imaging device.

As shown in FIG. **11**, the terrain of a hole or the entire course may be divided into cells in a matrix, each cell having its own ID number, so that the location of mobile unit **1** may be represented by a cell number. In cases where this cell system is applied, data of the respective directions and distances to the cells with respect to each imaging device 27_1~27_n, 27_c may be stored beforehand so that the appropriate imaging device 27_1~27_n, 27_c can be selected and controlled by directly using said data. Furthermore, the most suitable imaging device 27_1~27_n, 27_c to be used for each cell may be included in the cell data to be stored. Cells are formed by dividing the entire course of the terrain from the tee ground to the green of each hole into small areas in a matrix which measures, for example, 3 meters on a side.

Operation of the above embodiments is described hereunder.

In case of an emergency such as when a player is seriously injured or collapses, by operation of emergency button **11** of mobile unit **1** by the player himself or a person accompanying him, mobile unit **1** transmits an emergency signal as well as a locational signal indicating its own location, as determined by the location determining component described for FIG. **10**, above together with its ID data to receiver **21** of management unit **2**.

Alternatively, the system may be configured such that the location of mobile unit **1** is computed by location computing component **34** shown in FIG. **5** and that signals including the locational signal indicating the location computed by this location computing component **34** are received by receiver **21**. In this case, the location is determined based on signal receiving conditions of the plurality of relay devices 17_1~17_n. In other words, as distance l between two relay devices 17_1 and 17_2 is constant as shown in FIG. **6**, the location of transmitter **15** that transmitted the signals is determined by location computing component **34** by ascertaining the respective directions to transmitter **15** from relay devices 17_1 and 17_2, and the signals which include the locational signal indicating the current location of the specific transmitter **15** are transmitted to receiver **21**.

As a result, according to the ID data included in the signals received by receiver **21**, controller component **22** controls transmitter **23** to send signals to activate voice communication device **16** of mobile unit **1**, thereby allowing voice communication between voice communication devices **16** and **24**. A number of communication channels during normal circumstances can be reduced by preventing voice communication device **16** from being activated under normal circumstances and granting voice communication to only a specific mobile unit **1** in case of an emergency.

Based on the locational signal of receiver **21**, camera controller component **26** of controller component **22** is controlled so that imaging device controller component **26** selects the most suitable camera 27_1~27_n, 27_c according to the criteria set beforehand. Panning and tilting of imaging device 27_1~27_n, 27_c selected by camera controller component **26** is controlled in order to adjust the angle of its view.

Selected imaging device 27_1~27_n, 27_c determines the distance to the subject through control by camera controller component **26** or by automatic focusing using components incorporated in the camera itself, such as light emitting elements and photo-electric elements or, as shown in FIG. **7**, an ultrasonic transmitter ***27e*** and ultrasonic receiver ***27r***, with automatic focusing being performed by emitting light or signals from the light emitting elements or ultrasonic transmitter ***27e*** and computing the distance to the subject based on the length of time from when the light or the signals are emitted to when they are received by the photo-electric elements or ultrasonic receiver ***27r***.

At this time, imaging device 27_1~27_n, 27_c is zoomed so that the proportion of the image of the subject in relation to the size of the frame is constant as shown in FIG. **8**. In other words, when the distance from imaging device 27_1~27_n or 27_c to the subject is L, the height of the subject M, the focal length of the lens of the camera F, and the length of the image of the subject in the frame K as shown in FIG. **9**, K is approximately equal to F×M/L, if value L is sufficiently large. Therefore, granting that M is the average height of an adult and constant, K can be made constant by changing focal length F according to distance L to transmitter **15** which has been measured.

The signals representing visual images of the person who is injured or ill, these pictures being taken by imaging devices 27_1~27_n, 27_c, are received by visual image receiver component **28**. The visual signals and vocal signals, which have been received from voice communication device **16** through voice communication device **24**, are transmitted by relay device **25** through public lines respectively to visual image receiver component **32** and voice communication device **31** of remote unit **3**.

Further, where a doctor or other person using remote unit **3** wants specific pictures, the system may have such a configuration as to permit him to operate a dial or buttons or the like on voice communication device **31** to transmit DTMF signals through relay device **25** to the imaging device controller component **26** so that camera 27_1~27_n, 27_c is selected and controlled to perform zooming, panning and tilting. This can be done by a setting such that, for example, pushing **2** causes upward tilting; pushing **8** downward tilting; pushing **4** panning to left; pushing **6** panning to right; pushing **1** zooming up; pushing **7** zooming down; and pushing * and the ID number of the desired camera when changing cameras.

The configuration as above facilitates looking at visual images of the patient on the course in favorable conditions by means of remote unit **3** installed in a hospital or the like and also provides communication with mobile unit **1** through telephone or other means which serves as voice communication device **31**. As the invention thus makes it possible to know the conditions of the patient and give necessary directions for treatment of the patient and so forth, it has a merit in improving the effect of first aid treatment.

Further, as management unit **2** at a clubhouse can be connected to remote unit **3** at a hospital through public lines, installation of a system according to the invention is relatively easy.

Next, another embodiment is explained hereunder, referring to FIG. **12**.

The embodiment shown in FIG. **12** is a simpler version of the embodiment shown in FIG. **1** and does not have receiver **23** of management unit **2**. In this embodiment, communication between voice communication device **16** of mobile unit **1** and voice communication device **24** of management unit **2** is activated by operating emergency button **11**.

Omitting receiver **23** makes necessary an increased number of channels in order to avoid radio interference. On the other hand, it is advantageous in providing immediate communication.

Next, yet another embodiment is explained hereunder, referring to FIG. **13**.

The embodiment shown in FIG. **13** has the same configuration as the embodiment shown in FIG. **12** except that it is capable of monitoring various physical conditions. Furthermore, a system having the configuration as the embodiment shown in FIG. **1** may also have a means of monitoring physical conditions.

According to the configuration of the embodiment, transmitter **15** of mobile unit **1** is capable of being connected to a monitoring instrument **51** for various physical conditions, such as body temperature, pulse, blood pressure and so on, through a wire circuit or wireless means.

Said monitoring instrument **51** may be of various types: for example, a constantly-worn type to be worn all the time, which may be in the shape similar to a wrist watch and measures body temperature, blood pressure, pulse and so on from the temperature of the surface of the body and blood vessels around the wrist by means of a thermometer, a pressure gauge, an infrared sensor or the like; an in-contact-when-necessary type to be brought into contact with a part of body, such as inside the mouth or an arm, to measure body temperature, blood pressure, pulse and so on by means of a thermometer, a pressure gauge, an infrared sensor or the like whenever necessary; and a fixed-installation type installed at a fixed location such as at a rest area in a clubhouse or a shop on the grounds of the course. Said fixed-installation type may have the configuration which calls for inputting the ID date of the user through his mobile unit **1** or other means, and setting a part of the user's body, such as an arm, on the equipment to obtain information of his physical condition. In cases where the constantly-worn type or the in-contact-when-necessary type is used, data of body conditions is detected near the user's mobile unit **1**. Therefore, the data may be input into mobile unit **1** by connecting it to monitoring instrument **51** or, because they are at close range, through weak radio waves. In case of the fixed-installation type, data may be directly input to management unit **2** without going through mobile unit **1**.

Furthermore, mobile unit 1 is provided with a receiver **52** for receiving signals which inform of abnormal physical conditions. Upon receiving such warning signals from management unit **2**, receiver **52** gives warning by voice or sounding alarm, as well as displaying a message, such as "Body temperature is rising, presenting danger of heat stroke: Drink fluids and rest in a cool place", "Blood pressure above normal range: Stop game and return to clubhouse", "Irregular pulse: Stop game temporarily and rest at the nearest rest area for at least 30 minutes" or the like on liquid crystal display **5**.

Management unit **2** is provided with a physical condition storage component **53** for storing data of physical condition monitored by monitoring instrument **51** and transmitted from mobile unit **1**, physical condition storage component **53** storing transmitted data in the order of elapsed time from prior to starting the game and thereafter. Physical condition storage component **53** is also connected to relay device **25**.

Physical condition storage component **53** is also connected to ajudging component **54** which judges whether abnormal physical conditions are being experienced by comparing current conditions with those stored in physical condition storage component **53**. Further, judging component **54** is connected to a transmitter **55**, which transmits warning signals to receiver **52** of mobile unit **1** when physical conditions of the subject is judged to be abnormal.

Remote unit **3** is provided with a physical condition display component **55** which has image composite function and is capable of generating composite images representing physical conditions of a patient on the display.

Next, operation of the above embodiments shown in FIG. **13** is described hereunder.

Its operational procedure is basically the same as that of the embodiment shown in FIG. **12**.

First of all, store data of normal conditions of each player in physical condition storage component **53** beforehand by inputting it using keyboard **6** or assessing his physical conditions prior to starting the game by means of monitoring instrument **51**.

Then, during the game, check physical condition at regular intervals or whenever desired by means of monitoring instrument **51**. The data of this assessment is stored in physical condition storage component **53** in the order of elapsed time and also compared by judging component **54** with the data of the normal condition or the data of the

condition before starting the game, which is also stored in physical condition storage component **53**. In cases where any abnormal condition is detected in this judgement step, judging component **54** causes transmitter **55** to send out warning signals. When the warning signals have been transmitted, receiver **52** sounds an alarm and displays an appropriate message, such as those described above, on liquid crystal display **5**.

When emergency button **11** is activated, in addition to sound signals and visual signals of pictures taken by one of imaging devices 27_1~27_n, 27_c, data of physical conditions of the subject stored in physical condition storage component **53** is transmitted through relay device **25** to remote unit **3**.

In remote unit **3**, the physical condition data stored in physical condition storage component **53** is combined with pictures taken by imaging device 27_1~27_n, 27_c and displayed in the form of composite image. Physical condition data to be displayed includes data of normal condition, physical condition before starting the game and those obtained by assessment after starting the game, as well as the current condition. As these physical conditions are displayed in the order of elapsed time, with the changes of physical condition and the current state being thus presented, the changes in the condition of the patient can be reliably known.

Furthermore, the patient's chronic illness, allergies, current medication and other data may be stored in physical condition storage component **53** beforehand using ten-key pad **6** of mobile unit **1** or other means.

As it is possible to know about the physical condition of the person who has been injured or fallen ill, following the flow of time and in real time according to this embodiment shown in FIG. **13**, the embodiment ensures of giving appropriate care in an emergency and effective early-stage treatment.

Furthermore, the term "sender" referred to in the above explanation and appended claims, whose pictures are being taken, is not limited to the person who actually sends signals; it may also mean the injured or the sick person, who is at a location near the actual sender and whose physical conditions are monitored.

Having described preferred embodiments of the invention with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various changes and modifications may be effected therein by one skilled in the art without departing from the scope or spirit of the invention as defined in the appended claims.

I claim:

1. A communication method comprising the steps of:

transmitting signals from a sender by means of a mobile unit carried by said sender, said signals having a vocal and an informational component;

receiving said signals from said sender at a relay station;

selecting a selected imaging device from a plurality of imaging devices located at various positions of an area;

obtaining a visual image of said sender, said obtaining a visual image including controlling a plurality of imaging functions of said selected imaging device;

transmitting further signals from said sender together with said visual image from said relay station to a receiving party; and

transmitting vocal signals of said receiving party through said relay station to said sender responsively to at least one of said further signals and said visual image.

2. The communication method of claim **1**, wherein:

said informational component includes locational data for said sender's location;

said selecting a selected imaging device is responsive to said locational data; and

said controlling said plurality of imaging functions of said imaging device is responsive to said locational data.

3. The communication method of claim **2**, wherein:

said selecting a selected imaging device includes one of automatically selecting at said relay station and manually selecting by said receiving party; and

said controlling said plurality of imaging functions includes one of automatically controlling at said relay station and manually controlling by said receiving party.

4. The communication method of claim **3**, wherein said transmitting said informational component of said signals from said sender includes transmitting a physical condition datum of a subject.

5. The communication method of claim **4**, wherein said transmitting a physical condition datum includes the steps of:

monitoring a physical condition of said subject to produce a present physical condition datum;

providing a stored normal physical condition datum of said subject; and

correlatively transmitting said stored normal physical condition datum and said present physical condition datum.

6. A communication system comprising:

at least one imaging device;

at least one mobile unit having means for transmitting and receiving vocal and informational signals;

at least one remote unit having means for transmitting and receiving said vocal and informational signals;

said at least one remote unit having means for receiving visual signals

said at least one remote unit having means for displaying visual images responsively to said visual signals;

a management unit having means for individually controlling imaging functions of each of said at least one imaging device;

said management unit having a means for relaying said vocal, said visual, and said informational signals between each said at least one mobile unit means for transmitting and receiving and each said at least one remote unit means for transmitting and receiving; and

said management unit having means for concurrently receiving said visual signals from said at least one imaging device with said signals from said at least one mobile unit, and concurrently transmitting said visual signals from said at least one imaging device with said signals from said at least one mobile unit to said at least one remote unit.

7. The communication system of claim **6**, wherein said at least one remote unit has an override means for individually controlling imaging functions of each of said at least one imaging device.

8. The communication system of claim **7**, further comprising:

means for monitoring a physical condition of a subject, said means for monitoring having physical condition output data;

means for sending said physical condition output data to said mobile unit; and

said informational signals including said physical condition output data.

9. The communication system of claim 8, further comprising:

means for storing data of a normal physical condition of said subject; and

means for combining said normal physical condition data of said subject and said physical condition output data of said subject to form composite physical condition data;

said informational signals including said composite physical condition data.

10. The communication system of claim 9, further comprising:

means for combining visual images of said subject taken by said at least one imaging device with said output data of said subject's means for monitoring physical condition.

11. The communication system of claim 6, further comprising:

means for locating said at least one mobile unit; means for extracting locational data from said means for locating;

means for sending said locational data extracted by said means for extracting to said management unit;

said management unit having means for selecting said at least one imaging device responsive to said locational information received from said means for locating; and

said means for individually controlling controls said at least one imaging device selected by said means for selecting responsively to said locational information received from said means for locating.

12. The communication system of claim 7, further comprising:

means for locating said at least one mobile unit;

means for extracting locational data from said means for locating;

means for sending said locational data extracted by said means for extracting to said management unit;

said management unit having means for selecting said at least one imaging device responsive to said locational information received from said means for locating; and

said means for individually controlling controls said at least one imaging device selected by said means for selecting responsively to said locational information received from said means for locating.

13. The communication system of claim 8, further comprising:

means for locating said at least one mobile unit;

means for extracting locational data from said means for locating;

means for sending said locational data extracted by said means for extracting to said management unit;

said management unit having means for selecting said at least one imaging device responsive to said locational information received from said means for locating; and

said means for individually controlling controls said at least one imaging device selected by said means for selecting responsively to said locational information received from said means for locating.

14. The communication system of claim 9, further comprising:

means for locating said at least one mobile unit;

means for extracting locational data from said means for locating;

means for sending said locational data extracted by said means for extracting to said management unit;

said management unit having means for selecting said at least one imaging device responsive to said locational information received from said means for locating; and

said means for individually controlling controls said at least one imaging device selected by said means for selecting responsively to said locational information received from said means for locating.

15. The communication system of claim 10, further comprising:

means for locating said at least one mobile unit;

means for extracting locational data from said means for locating;

means for sending said locational data extracted by said means for extracting to said management unit;

said management unit having means for selecting said at least one imaging device responsive to said locational information received from said means for locating; and

said means for individually controlling controls said at least one imaging device selected by said means for selecting responsively to said locational information received from said means for locating.

* * * * *

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Moengen

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(45) **Date of Patent: Apr. 16, 2002**

(54) **METHOD AND SYSTEM FOR MANIPULATION OF OBJECTS IN A TELEVISION PICTURE**

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(52) **U.S. Cl.** **345/848**; 345/726; 345/849; 345/632; 345/419; 345/427; 348/25; 348/157; 473/415; 342/453

(58) **Field of Search** 345/848–849, 345/726, 719, 716, 156, 419, 427, 632–633, 672, 682–683, 629; 348/25, 29, 157, 159, 169, 589; 382/103, 154; 473/415, 570, 569; 273/371, 317; 700/91; 702/150, 152; 342/125–126, 450–451, 453, 463

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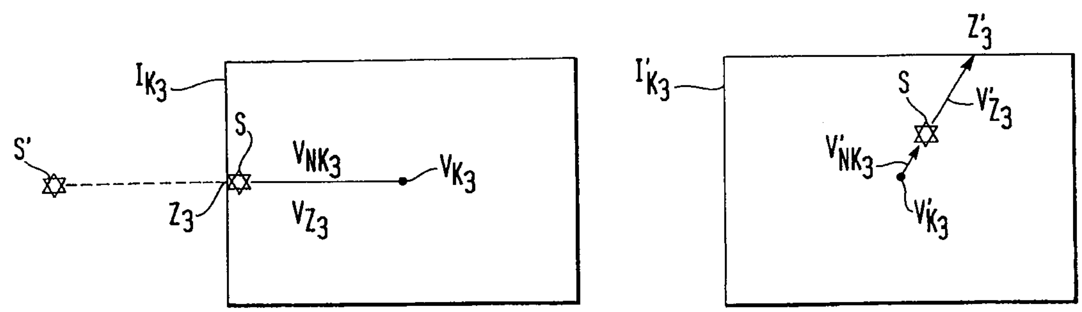
(57) **ABSTRACT**

In a method for manipulation of a movable object displayed in a television picture, the distance between the object and fixed basic positions is detected at a time t together with the distance between the object and a television camera in a known position. The object's position is converted to a position X,Y in the television camera's picture plane, generating therein a synthetic object which overlays the movable object and represents it in the television picture. In a method for generating a synthetic track which represents the path of a movable object displayed in television pictures during a period θ, the path of the object is calculated on the basis of its detected positions, and these positions are used for generating a synthetic track which is displayed in a television picture in order to represent the path of the object in the period T.

20 Claims, 9 Drawing Sheets



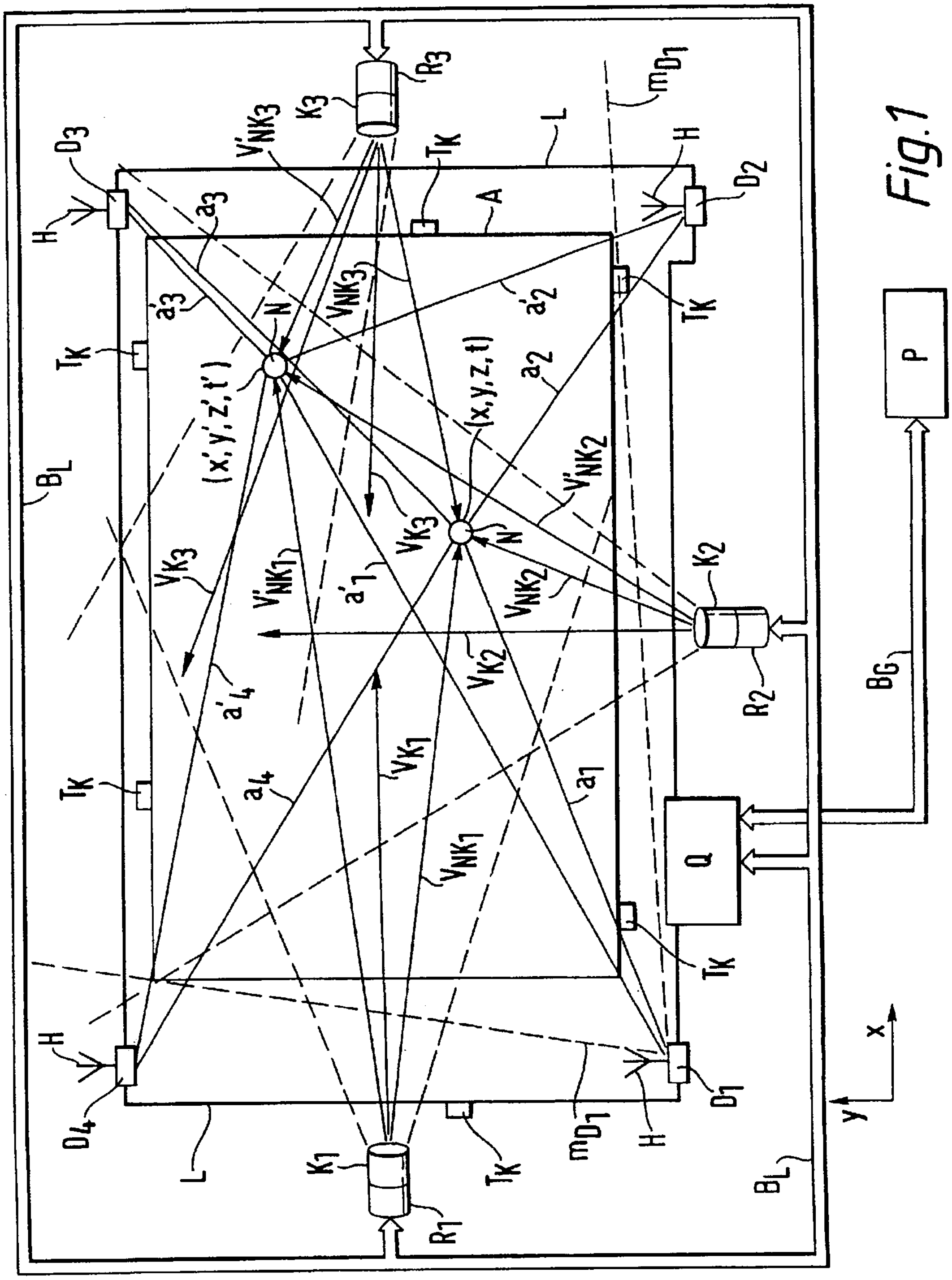

R3
K3
V'_{NK3}
T_K
L
m_{D1}
H
D_3
D_2
a_3
A
a'_3
N
V_{NK3}
a'_2
T_K
(x',y',z',t')
(x,y,z,t)
a_2
B_L
V'_{NK2}
V_{K3}
N'
V'_{NK1}
a'_1
V_{NK2}
K2
V_{K2}
a'_4
R2
B_G
P
V_{K1}
a_4
a_1
Q
V_{NK1}
D_4
D_1
K1
R1
x
y

Fig.1

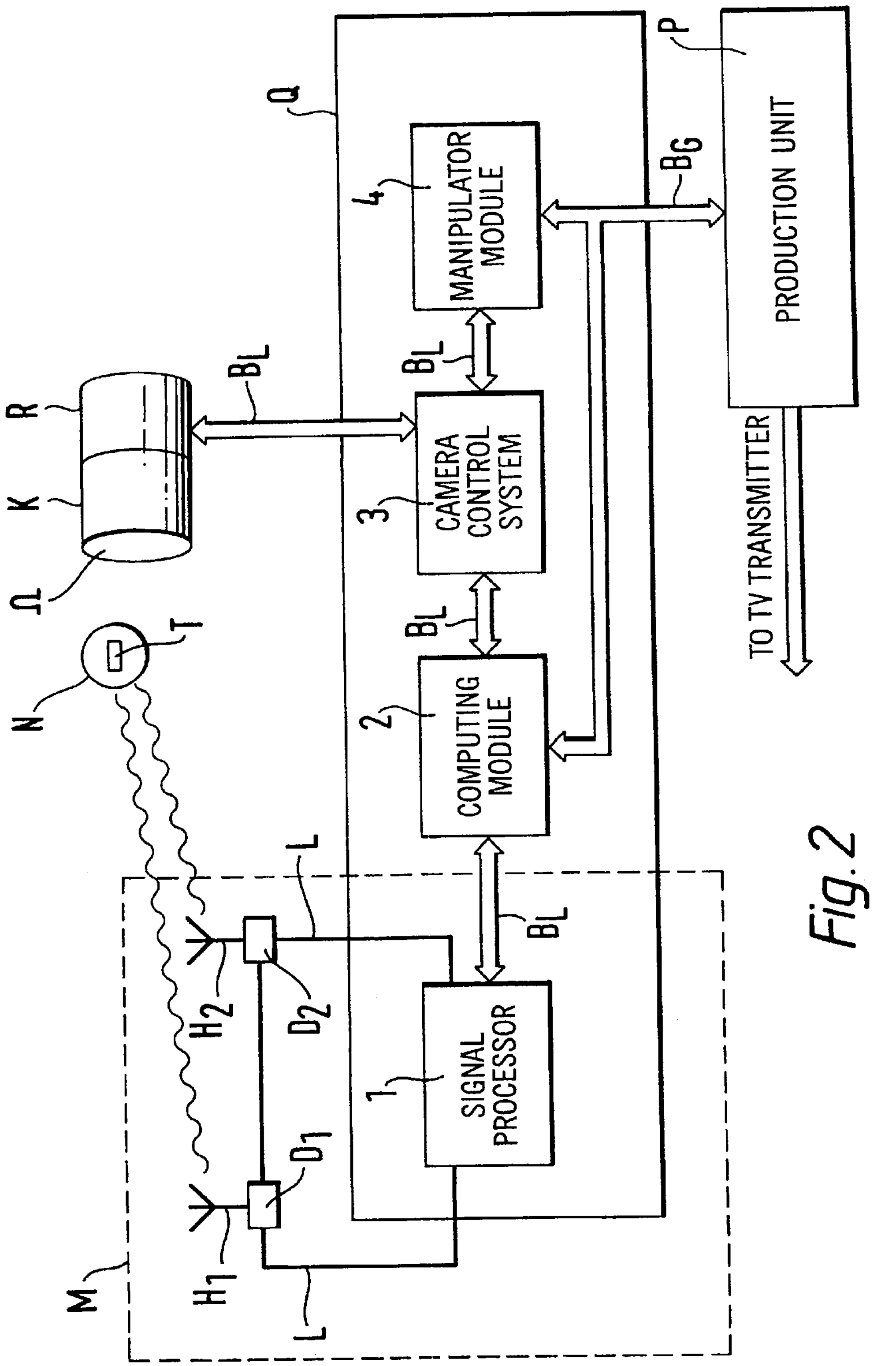

MANIPULATOR MODULE
CAMERA CONTROL SYSTEM
COMPUTING MODULE
SIGNAL PROCESSOR
PRODUCTION UNIT
TO TV TRANSMITTER
Q
P
B_G
B_L
B_L
B_L
B_L
4
3
2
1
R
K
Ω
N
T
L
L
H_2
D_2
D_1
H_1
M

Fig. 2

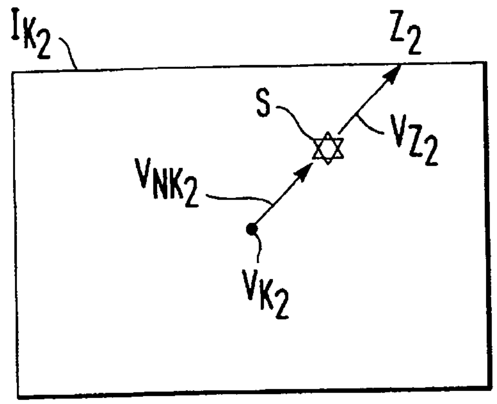


Fig.3a

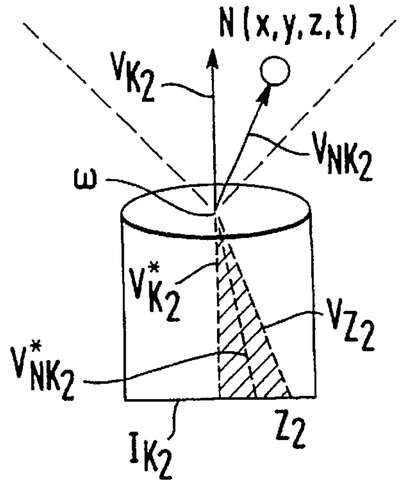


Fig.3b

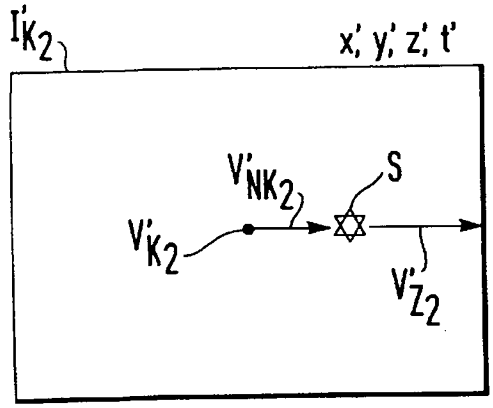


Fig.3c

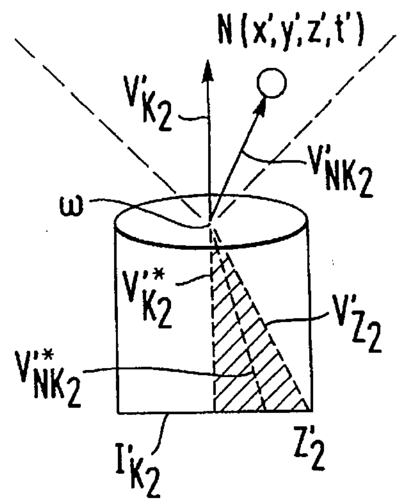


Fig.3d

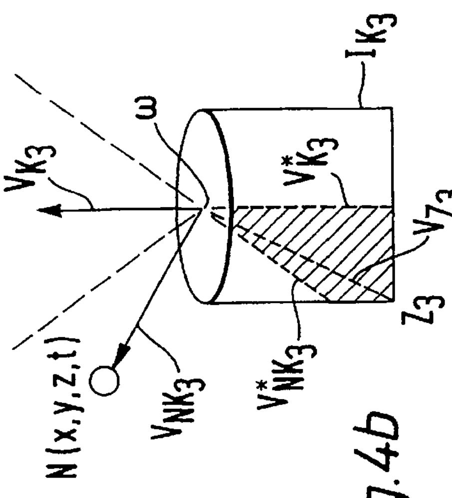


Fig.4b

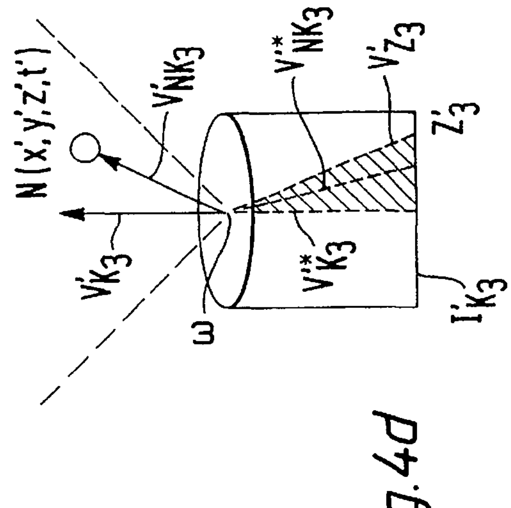


Fig.4d

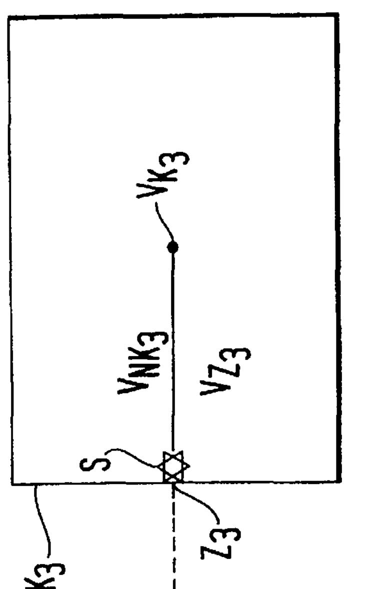


Fig.4a

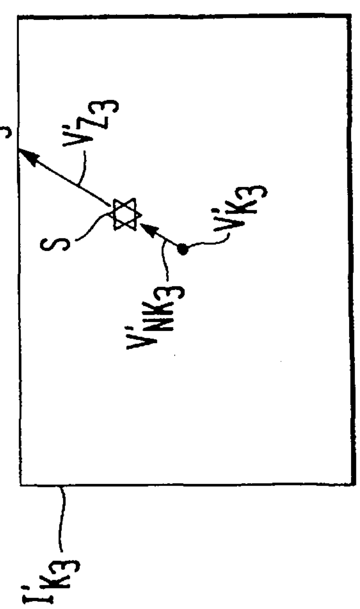


Fig.4c

Evidence Appendix
Appellant's Brief, page 86

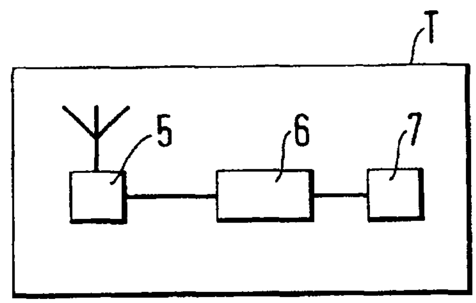


Fig.5

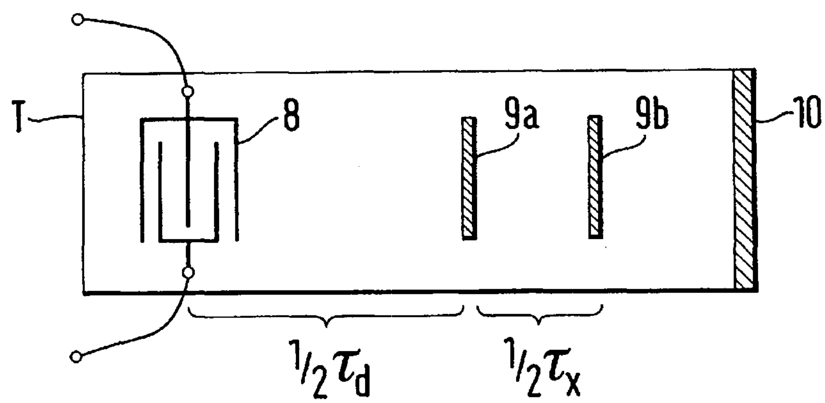


Fig.6

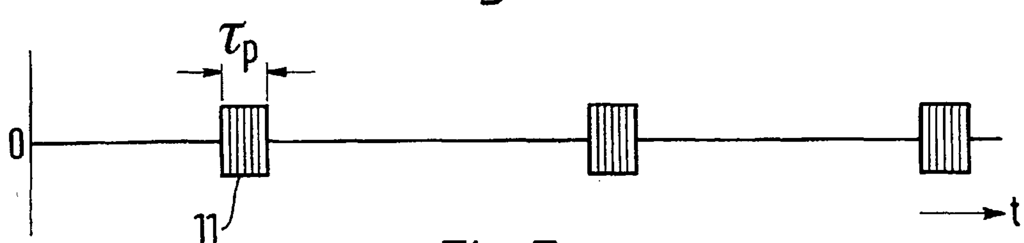


Fig. 7a

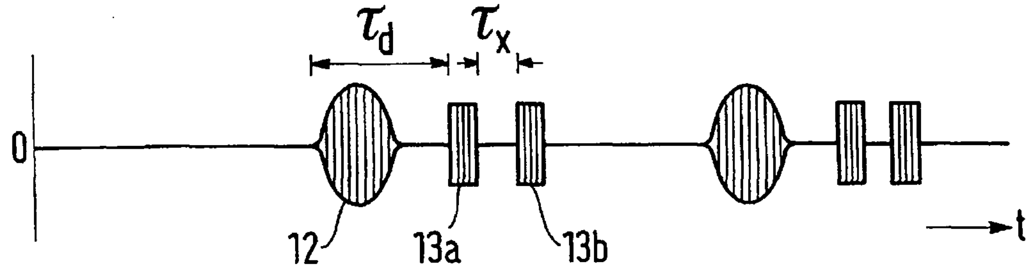
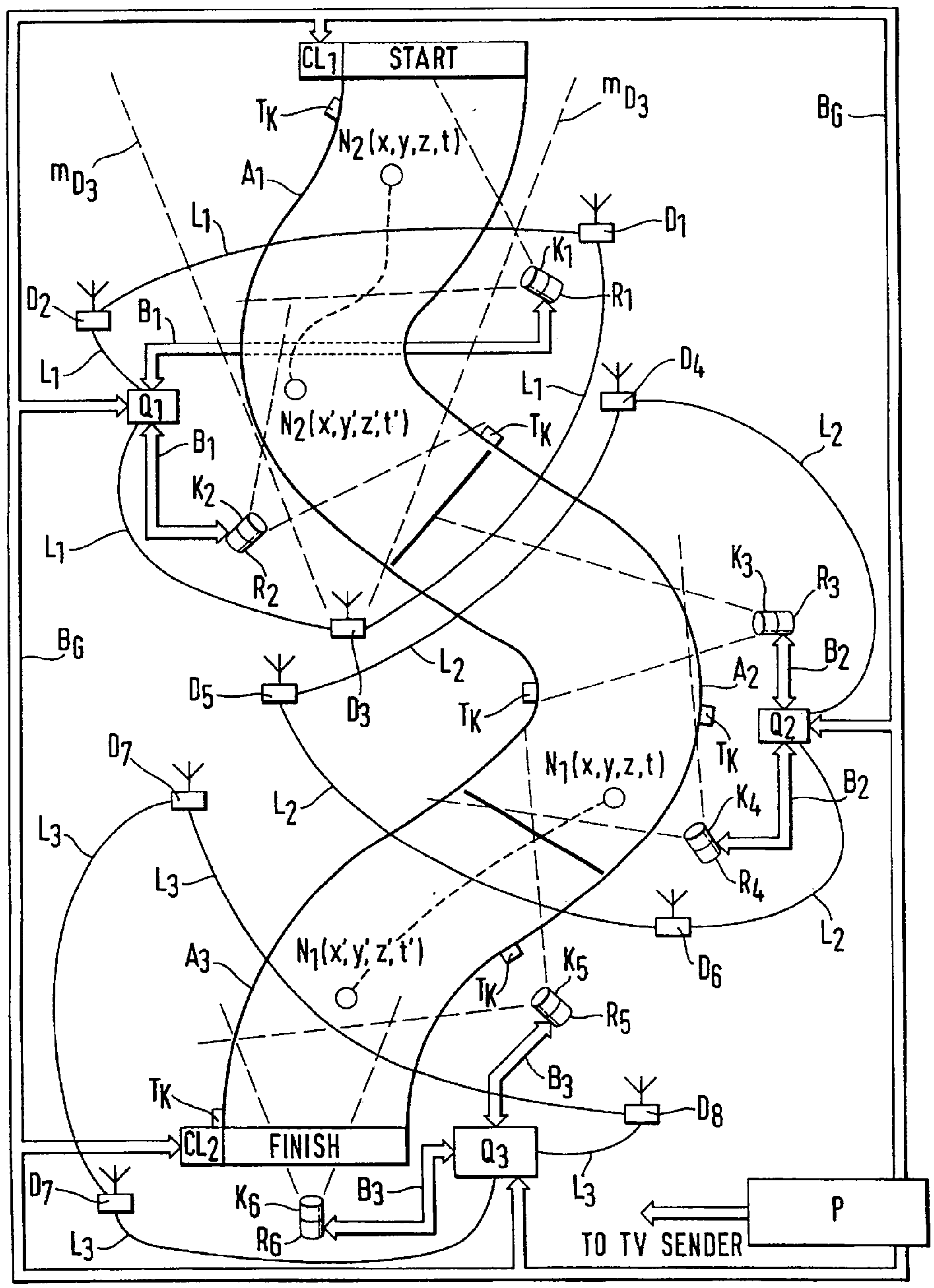


Fig. 7b



CL1
START
mD3
mD3
BG
TK
N2(x,y,z,t)
A1
L1
D1
K1
R1
D2
B1
L1
Q1
D4
L1
N2(x',y',z',t')
TK
L2
B1
K2
L1
R2
K3
R3
BG
L2
B2
D5
D3
TK
A2
Q2
TK
D7
N1(x,y,z,t)
B2
L3
L2
K4
L3
R4
L2
D6
A3
N1(x',y',z',t')
TK
K5
R5
B3
TK
D8
CL2
FINISH
Q3
D7
K6
B3
L3
P
L3
R6
TO TV SENDER

Fig. 8

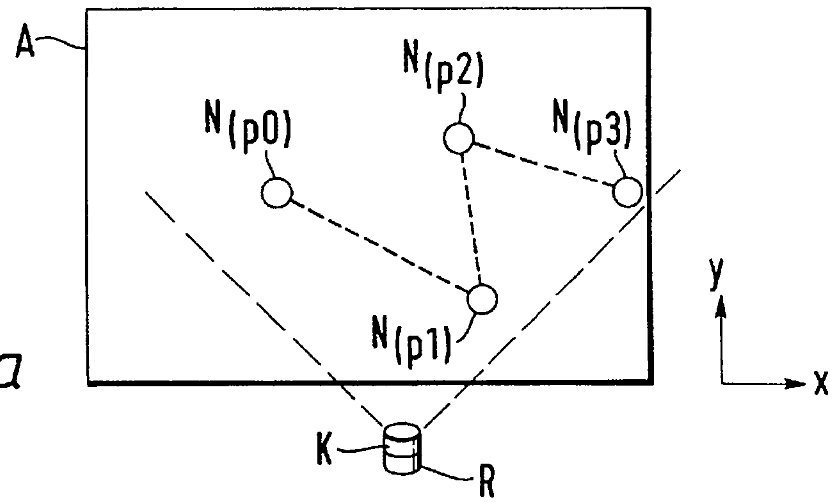


Fig.9a

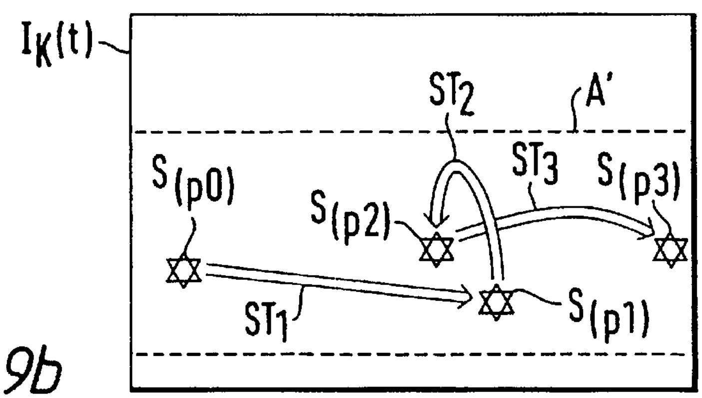


Fig.9b

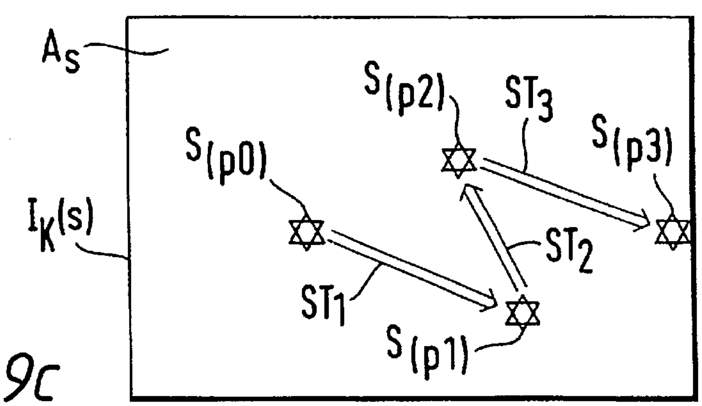


Fig.9c

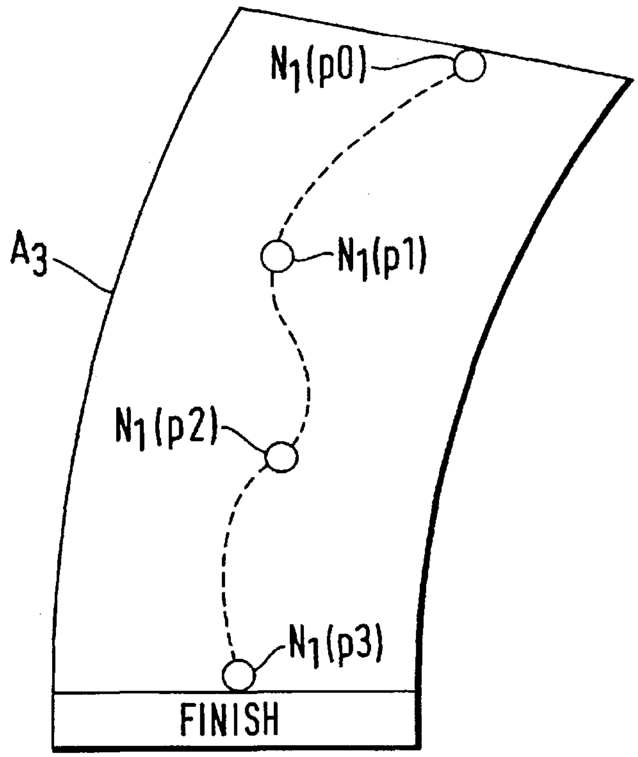


Fig.10a

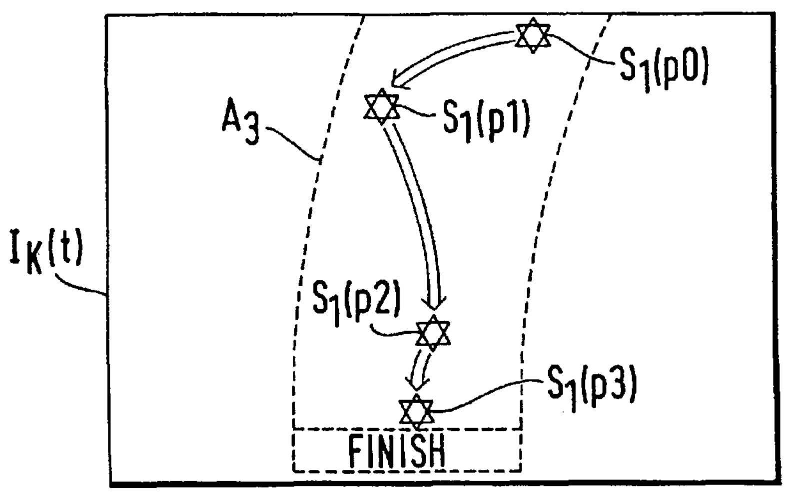


Fig.10b

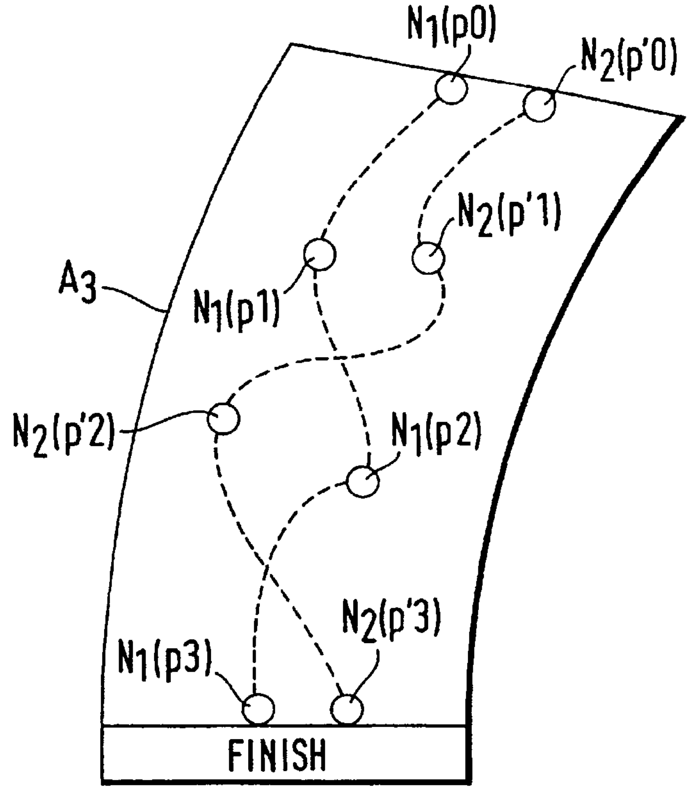


Fig.11a

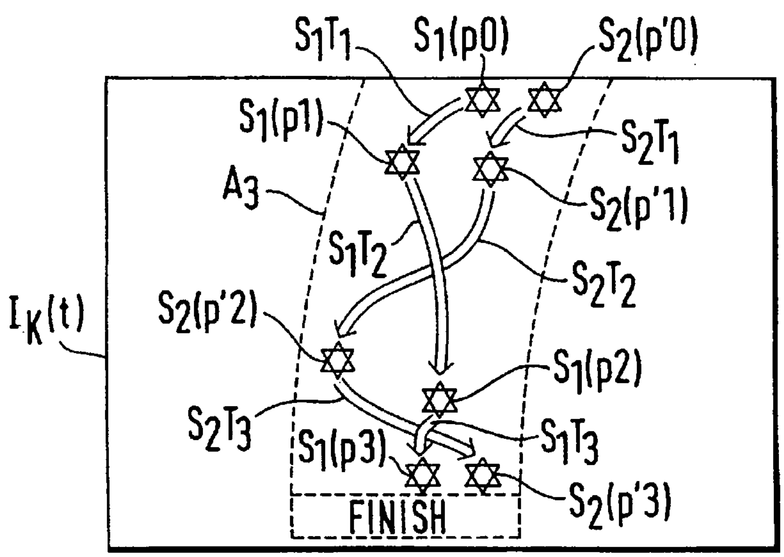


Fig.11b

METHOD AND SYSTEM FOR MANIPULATION OF OBJECTS IN A TELEVISION PICTURE

BACKGROUND OF THE INVENTION

The invention concerns a method for manipulation of at least one movable, natural object in a natural television picture, wherein the television picture is generated by one or more television cameras. The invention also concerns a method for generating at least one synthetic track in a television picture, wherein the synthetic track represents the path of a movable natural object in a natural television picture during a given period θ, and wherein there is employed a method for manipulation of the movable, natural object in the television picture. Finally, the invention concerns a system for implementation of the method for manipulating at least one movable, natural object in a natural television picture, wherein the television picture is generated by one or more television cameras, together with implementation of the method for generating a synthetic track in a television picture, wherein the synthetic track represents the path of a movable, natural object in the television picture during a given period θ, and wherein a method is employed for manipulating the movable, natural object in the television picture.

In television broadcasts where a movable, natural object plays a central part in the broadcast, it can often be difficult to follow the object or the movement thereof in the television picture. This is the case, e.g., in sports broadcasts from various ball games, such as football, handball, tennis, golf and ice hockey, where the picture format used, the background of the picture, colour, light conditions etc. can make it difficult to follow the object or the movement thereof. The object may also be invisible for a brief or a considerable period because it is masked by other objects in the picture. Such problems can be a factor in influencing the popularity of the television broadcasts, which in turn can have consequences for the sponsors' choice of programs or purchase of commercials in such programs, since the viewing figures are not as high as is desirable.

In order to make a game like ice hockey more attractive to the television medium, on the basis of the usual complaint about television coverage of ice hockey matches that the puck is difficult to follow, it has been proposed to make the ice hockey puck more clearly visible in the television picture by employing a special puck which is equipped with a number of infrared emitters driven by a battery provided in the puck. On the rink the puck is tracked by sensors placed along the edge of the rink, the sensors transmitting information to a camera which is connected to a computer. The information is fed to a data processing centre where a signal is generated which is processed graphically and introduced into the television picture. The puck can thereby be caused to change shape or colour. This system has been introduced by the company Fox Sports in the USA and is employed to represent the puck, e.g., surrounded by a shining halo in some colour or other and equipped with a coloured "comet tail" when the puck is in motion, e.g. at a certain speed. The colours can, however, be altered according to the wishes of the producer. In a practical embodiment of this system which is called "FoxTrax", 16 sensors are employed around the rink and two infrared cameras which also follow the puck. The processed representation of the puck is introduced into the television pictures which are recorded by the normal television cameras, and the special colour effects such as the halo and the "comet tail" are overlaid the television signal

with a delay which is not greater than between ⅙ and ⅓ of a second. "FoxTrax" is described in U.S. Pat. No. 5,564,698.

However, the system is complicated and offers limited opportunities for manipulation of the object, i.e. the picture of the puck. Another drawback is that the infrared emitters in the puck are driven by a battery which has a limited life, with a life of only 10 minutes having been quoted. This, however, is sufficient to allow the puck to be replaced during change of sides in a period of an ice hockey match, but makes a similar system less suitable in games where the object, i.e. the puck or ball, is in play for a longer period.

U.S. Pat. No. 4,675,816 (Brendon & Vinger) discloses a method for electronic localization of the ball in American football. The object of the method is to determine whether the ball has moved 10 yards forwards and provides simultaneous precise localization information about the ball and the possibility of positioning the football on the field. This method is regarded as an aid for spectators, officials and television. It comprises steps for providing a radio transmitter in the football and transferring radio signals from the football to a number of rotating receiver antennas, the antenna being directed towards the radio transmitter in such a manner that the radio waves supply accurate angular direction signals which can be used to calculate the position of the radio transmitter and the football on the field. These angular direction signals are supplied to a microprocessor which calculates the position of the transmitter and the football, with the use of a triangulation method which includes a computation stage which also indicates how far the ball has moved forwards, and the results of this computation stage can be shown on display units with a view to spectators and television viewers as well as being transferred to a control unit which is employed by the officials in order to monitor the course of the game.

From U.S. Pat. No. 5,138,322 (Nuttel) there is also known a system for continuous and precise measurement of the positions of a generally symmetrical object, such as a tennis ball, which is in motion in a predetermined three-dimensional area, such as a tennis court. In this case a number of antennas are employed which transmit radar signals to the three-dimensional area, reflected return signals from the ball being detected and compared with the transmitted signals for phase determination of the return signals, thus enabling unambiguous distances to the object or the ball to be determined. For this purpose a statistical method is employed in order to achieve an accurate determination of distance. The path of the object or the ball can be calculated simultaneously, and the system is calibrated by placing signal reflectors in different fixed positions on the court. A Doppler radar technique is employed.

Furthermore, in U.S. Pat. No. 5,346,210 (Utke & al.) there is disclosed an object localisation system, especially for localizing the ball in a special playing situation in American football. The system employs three sensors placed on one side of the field and a calibration source placed on the other side. The calibration source transmits an ultrasound signal which is received by the sensors and a ball marking unit which can be placed on the field instead of the ball also transmits an ultrasound signal which is received by the sensors, together with an RF signal which is received by the calibration source in order to switch it off. The sensors emit signals which are used by a processing unit to calculate time delays in order to determine the ball's position. Alternatively, the ball marking unit may only transmit an RF signal which is received by the sensors which in turn emit signals which are processed in order to determine time delays between the receipt of the signals in the sensors. In

addition, an automatic ball marking unit which is moved on a track is controlled by the processing unit in order to create automatically a visual representation of the position of the ball.

None of the above-mentioned, known systems, however, is particularly well suited to achieve full freedom to manipulate the picture of a natural object in a television picture, all requiring the use of relatively expensive and complicated systems. Nor are they suitable for all types of games or sports and moreover they appear to be substantially restricted to use in sporting events, but other forms of television broadcasts are, however, conceivable, where it will be equally interesting to be better able to visualise a movable object in a television picture with suitable detection and processing methods.

SUMMARY OF THE INVENTION

Consequently, it is a first object of the present invention to provide a system for manipulating the picture of at least one movable, natural object in a natural television picture in such a manner that the object's position and movement are clearly visible in the television picture.

A second object of the present invention is to provide a synthetic representation of the natural object, thus enabling the synthetic representation to appear as a synthetic object in the television picture and to represent the natural object's movement and position.

A third object of the present invention is to manipulate the synthetic object in the television picture with regard to shape and colour in such a manner that the viewer will have no trouble in following the object.

A fourth object of the present invention is to determine the path of a movable, natural object and to visualise this path in the form of a synthetic track for the object in the television picture.

Finally, it is an object of the present invention to provide a system which makes it possible to detect the movement of such a natural object and to process the detected data in order to generate and manipulate a representation of the movable object in a television picture as well as generating a synthetic track which represents the movement of the natural object in the television picture.

The above-mentioned objects and other advantages are achieved with a method which according to the invention is characterized by detecting the distance between the object and at least 2 fixed basic positions in a preselected x,y,z co-ordinate system at a time t, each basic position corresponding to a known position of a detector, determining an x,y,z co-ordinate for the object in the preselected x,y,z co-ordinate system at the time t, determining the distance between the camera's lens centre and the object at the time t as an object vector in the preselected co-ordinate system, determining the television camera's optical axis in the preselected co-ordinate system at the time t as a camera vector in the preselected co-ordinate system, determining a line from the television camera's lens centre to the point of intersection between the edge of the generated television picture and the plane formed between the object vector and the camera vector at the time t as a zoom vector, the object vector being located between the camera vector and the zoom vector when the object is visible in the television picture at the time t, and when the object is not visible in the television picture at the time t the zoom vector is located between the camera vector and the object vector, and determining an X,Y position of the object referred to the television camera's picture plane and the camera vector on the basis of the object vector and the camera vector at the time t, and if the object vector is located between the camera vector and the zoom vector, to insert a synthetic object in the X,Y position in the television picture at the time t, the synthetic object constituting a representation of the natural object recorded by the camera at the time t, or if the zoom vector is located between the camera vector and the object vector at the time t, to insert a symbol in the television picture, the symbol indicating the location of the X,Y position of the natural object outside the edge of the picture referred to the television camera's picture plane and the camera vector.

The above-mentioned objects and advantages are further achieved with a method which according to the invention is characterized by calculating the path of the natural object on the basis of detected positions x,y,z for the natural object in a preselected x,y,z co-ordinate system at the time t, where $t \epsilon \theta$, converting the detected positions at the time t to an X,Y position in the television camera's picture plane at the time t, and generating the synthetic track in the television picture as the connecting line between all X,Y positions for the natural object in the picture planes of the natural television pictures which are recorded sequentially during the period θ.

The above-mentioned objects and advantages are further achieved by implementing the stated methods according to the invention with a system which according to the invention is characterized in that it comprises a transponder provided in the natural object and arranged to react to an optical, acoustic or electromagnetic signal received by the transponder with transmission of a response signal, at least one position module with at least 2 position detectors for transmitting optical, acoustic or electromagnetic signals and receiving response signals from the transponder and provided in respective basic positions in a preselected x,y,z co-ordinate system, together with a signal processor 1 arranged to determine the distance between a position detector and the object at a time t, a computing module connected with the signal processor and arranged to compute the x,y,z co-ordinates for the object in the preselected co-ordinate system at the time t and on the basis of the computed x,y,z co-ordinates for a number of times t to calculate a path for the object, together with an object vector given by the distance between the camera's lens centre and the object at the time t, a camera vector given by the camera's optical axis at the time t and a zoom vector between the camera's lens centre and the point of intersection between the edge of the picture and the plane formed between the object vector and the camera vector at the time t, the object vector being either located between the camera vector and the zoom vector or the zoom vector between the camera vector and the object vector, a camera control system connected with the computing module and arranged to detect or generate values for the camera settings, and a manipulator module connected with the camera control system and the computing module and arranged to a) create a synthetic object in an X,Y position for the natural object in the recorded television picture at the time t, the synthetic object constituting a representation of the natural object recorded by the camera at the time t or b) create a symbol in the television picture, the symbol indicating the X,Y position for the natural object outside the edge of the picture at the time t, c) generate and select attributes for the synthetic object, or d) generate at the time t a synthetic track in a recorded or generated television picture, the synthetic track representing the path for the natural object during a period θ before or up to the time t.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be discussed in more detail in connection with embodiments and with reference to the accompanying drawing, in which:

FIG. 1 illustrates a design of the system according to the present invention, e.g. in connection with a ground for a ball game,

FIG. 2 is a block diagram of components in a device for processing the detected signals in the system according to the present invention,

FIGS. 3*a, b, c, d* are a representation of the object in the picture plane of a television camera,

FIGS. 4*a, b, c, d* are a representation of the object in the picture plane of a second television camera, where the object is partially located in positions outside the picture plane,

FIG. 5 is a block diagram of a transponder employed in the system according to the present invention and based on microwave technique,

FIG. 6 is an active transponder for use with the invention and based on an acoustic surface wave component,

FIG. 7*a* is a polling signal emitted in the form of pulses from a position detector,

FIG. 7*b* is a response signal emitted in the form of a pulse sequence from the acoustic surface wave component,

FIG. 8 is a system according to the present invention implemented for detection of several objects which are in motion in separate or connected areas,

FIGS. 9*a, b, c* illustrate generation of a synthetic track by means of the design according to FIG. 1,

FIGS. 10*a, b* illustrate generation of a synthetic track by means of the design according to FIG. 8, and

FIGS. 11*a, b* illustrate generation of synthetic tracks for two objects by means of the design according to FIG. 8.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates the present invention realised at a sports centre, such as a ground for ball games or an ice hockey rink A, where the area A is the projection in an x,y plane of the area which has to be covered by position detectors $D_1, \ldots D_4$. The detectors are connected via a signal line L to a data processing unit Q. The data processing unit Q is further connected via a local data bus B_L to a regulator module R_1, R_2, R_3 which is assigned to respective television cameras K1, K_2, K_3 and comprises not shown bodies, preferably in the form of servos, for setting the cameras together with not shown sensors for detection of the camera settings, including camera angles and zoom angles. The position detectors $D_1, \ldots D_4$ comprise as shown antennas H, and these are directive, with their main lobes m_H substantially covering the area A and a certain height above the plane of the area A. In FIG. 1 the main lobe for the position detector D_1 is indicated by broken lines M_{D1}. Both the position detectors $D_1, \ldots D_4$ and the television cameras K_1, K_2, K_3 are positioned in a preselected x,y,z co-ordinate system, since the plane of the rink A as mentioned may lie in the co-ordinate system's x,y plane, the z axis then being perpendicular to the x,y plane (orthogonal co-ordinate system). The positions of both the position detectors $D_1, \ldots D_4$ and the cameras K_1, K_2, K_3 are precisely defined in the x,y,z co-ordinate system. In the area A, i.e. on the rink or over it at a certain height there is located a movable object N which is illustrated in FIG. 1 in two positions x,y,z and x',y',z' at the times t and t' respectively. In other words, during a time interval $\theta = t' - t$ the movable object has moved from the position x,y,z to the position x',y',z'. The cameras K_1, K_2, K_3 are directed towards the area A and are set so as to cover a picture field of a certain size, in FIG. 1 for each camera indicated by broken lines. The picture axis or the optical axis in a camera K is represented by a vector called the camera vector V_K, e.g. for camera K_2, V_{K2}. The camera vector V_K passes through the camera's lens centre and the picture field's geometrical centre axis. The cameras K_1, K_2, K_3 which are used naturally have zoom lenses, and the picture fields can thereby vary in size according to how the cameras K_1, K_2, K_3 are zoomed. Along the edge of the rink transponders T_K are provided in fixed positions for calibration of the position detectors $D_1, \ldots D_4$. Corresponding transponders may furthermore also be provided both in the position detectors $D_1, \ldots D_4$ and the cameras K_1, K_2, K_3.

The connecting line between the lens centre in a camera K and the object N which may be a ball or puck or any other movable object, is called the object vector and designated by V_N, V_{NK2}, e.g., being the object vector for the camera K_2 at the time t and V'_{NK2} the object vector for the camera K_2 at the time t'. The same applies to the other cameras. The distance from a position detector D to the object N at the time t is designated as a and at the time t' as a', for example for the position detector D_1 as a_1 and a'_1 respectively.

When a polling signal is emitted from a position detector D, after a certain period τ a response signal is received from the natural object N. The response signal may be a reflection of the polling pulse or it may be a response pulse from the object N, the response pulse being triggered by the polling signal from the position detector D. The time between the transmission of the polling signal and receipt of the reply signal, i.e. τ, now becomes a measurement of the distance a between a position detector D and the object N. For example, the position detector D_1 finds that the distance to N at the time t is a_1, and at the time t' a'_1. The same applies to the remaining position detectors. If the object N is now located all the time on the x,y plane in the area A, its position will be unambiguously determined by using two position detectors, e.g. D_1 and D_2 and finding respective distances a_1, a'_1; a_2, a'_2. If the area A is three-dimensional, i.e. the position to the object N is determined by the co-ordinates x,y,z at the time t, it is necessary to have at least three position detectors, for example D_1, D_2, D_3. As illustrated in FIG. 1 four position detectors $D_1, \ldots D_4$ are preferably used to achieve unambiguous detection of the position of the natural object N. The position of the object N is thereby solely determined by distance measurements, i.e. by trilateration, a method which is well known to those skilled in the art and therefore will not be discussed further here. Thus, as distinct from distance determination by triangulation, it is not necessary to determine direction angles to the object N. Moreover, in the actual position determination a statistical optimization may advantageously be employed in order to reduce any positioning errors, such as estimation by means of the least squares method.

As illustrated in FIG. 2, according to the invention the system comprises a transponder T provided in the natural object N. The transponder T may be a passive transponder, such as a reflector for microwave signals or radar signals transmitted by the antenna H in the position detector D or it may be an active transponder which is triggered by the polling signal transmitted by the position detector D and emits a response signal which is detected by the position detector D. The position detector D with antenna H forms part of a position module M which comprises a signal processor 1, the signal processor 1 preferably being provided in a data processing unit Q. The signal processor 1 is connected via the signal line L with, for example, two or more position detectors $D_1, \ldots,$ finding the detection distance a on the basis of the measured running times τ. For this purpose there will be provided in the signal processor 1

components which are well known to those skilled in the art, including a clock with a very high clock rate, the clock rate at least being adapted to the frequency for the polling signals emitted from the position detectors D. The detected distances a are given to a computing module **2** which by means of trilateration calculates the positions x,y,z at different times t and thereby also the path of the object N on the basis of positions detected at the different times t. The computed positions are supplied to a camera control system **3** in the data processing unit Q. In the camera control system **3** values are calculated for the settings of the camera K by means of a regulator module assigned to the camera K, and the camera settings can be controlled automatically by means of a control loop provided in the camera control system **3**, on the basis of the existing camera settings and detected positions for the object N. The optical system (objectives and other lenses) in the camera K are indicated schematically and designated by Ω.

The regulator module R comprises not shown servos for generating the camera settings and not shown sensors for detection and recording of the camera settings. One of the sensors is an angle sensor for determining the camera angle, and use is preferably made of a triaxial angle sensor which thereby indicates the direction of the camera's optical axis or the camera vector V_K. The angle sensor can be calibrated by measuring the angle of direction at a fixed point. Such angle sensors are well known to those skilled in the art and therefore do not require further mention here. The camera K can naturally also be manoeuvred manually in order to set zoom angles and camera angles.

The data processing unit Q also comprises a manipulator module **4** for generating a synthetic object S which corresponds to the natural object N, the fixed position of the natural object being converted and scaled to a corresponding (projected) position X,Y in the picture plane of the camera K, taking into account the recorded values for the camera settings. Thus in the position X,Y in the camera's picture plane, via, e.g., a video generator (not shown) provided in the manipulator module **4**, a synthetic object S can be created, representing the natural object N in its position X,Y in the picture plane in the camera K, and the synthetic object S can be represented with various attributes for size, shape and colour. The primary object here is that the synthetic object S which represents the natural object N should at all times display the position and/or the movement of the natural object N, as it would be represented in the television picture at any time t.

The signal processor **1**, the computing module **2**, the camera control system **3** and the manipulator module are all interconnected via the local data bus B_1, which also passes signals to and from the camera's regulator module R. If a plurality of television cameras K are assigned to the data processing unit Q, they are also naturally connected to the local data bus B_L. From the data processing unit Q a global data bus B_G leads to a production unit P which takes care of the actual production of the television broadcast and may transfer the pictures to the television station or the television transmitter.

In the production unit P there are displayed the natural television pictures recorded at any time, or possibly synthetically generated television pictures with a synthetic object S and the recorded television pictures with the synthetic object overlaid in the correct position, thus enabling the producer to select the camera and the picture which is desired to be represented at any time during a television broadcast and transmit the pictures via a standard TV line to the television transmitter. If only a data processing unit Q is employed, the production unit P and the data processing unit Q may preferably be integrated into one unit, but if a plurality of data processing units are provided, the system may be completely decentralised, with all the data processing units thus being connected to the production unit via the global data bus B_G.

The representation of the synthetic object S in a television picture will now be described in more detail with reference to FIGS. **3** and **4**. As illustrated in FIGS. **3***a* and **3***b*, camera K_2, for example, records in a known position and with a known camera angle and zoom angle at time t a television picture in the picture plane I_{K2}. The camera vector V_{K2} is normally located on the picture plane I_{K2} in the centre thereof. The natural object N which at the time t is located in the x,y,z position has the object vector V_{NK2} which forms an angle with the camera vector V_{K2} and passes through the lens centre ω. As can be seen in FIG. **3***b*, the two vectors V_{K2} and V_{NK2} form a plane which intersects the edge of the picture plane I_{K2} at the point Z_2. The connecting line between the lens centre ω and the point Z_2 is called the zoom vector V_{Z2}, as illustrated in FIG. **3***b*, and is thereby determined by the camera settings. The representations of the remaining vectors in the optical system Ω are marked with a star, for example V^*_{K2} for the camera vector and V^*_{NK2} for the object vector. The zoom vector V_{Z2} also forms an angle with the camera vector V^*_{K2} as illustrated in FIG. **3***b*. If the angle between the zoom vector V_{Z2} and the camera vector V^*_{K2} is greater than the angle between the object vector V^*_{NK2} and the camera vector V^*_{K2}, the natural object is reproduced in the picture plane I_{K2} and in FIG. **3***a* illustrated represented by a star-like object which constitutes the synthetic object S. In FIG. **3***c* the natural object N has moved to the position x',y',z' at the time t' and the vector parameters for the dynamic vectors, i.e. the object vector V_N and the zoom vector V_Z has changed, so that they are illustrated in FIG. **3***c* as V'_{NK2} and V'_{Z2} respectively. The same applies to FIG. **3***d* which shows the representation of the vectors in the optical system and is marked in the same way as in FIG. **3***b*. The natural object N is still in the picture field and can be represented by the synthetic object S. In FIG. **4** the picture plane I_{K3} is shown at two different times t and t' for the camera K_3. At the time t the position x,y,z of the natural object falls outside the camera's picture field. As illustrated in FIG. **3***b* the angle between the camera vector V^*_{K3} and the object vector V^*_{NK3} is greater than the angle between the zoom vector V_{K3} and the camera vector V^*_{K3}. In other words the object is outside the edge of the picture. This may be advantageously indicated in the television picture by placing the synthetic object S or an indicator therefor at the edge of the picture, i.e. at the point Z_3, the line between the centre of the picture and the synthetic object indicating the direction of the synthetic object. Naturally, a synthetic direction indicator can also be employed to point to the object's position outside the edge of the picture. In FIG. **4***b* which illustrates the picture plane I'_{K3} at the time t' the movable or natural object N has moved into the picture field and can be represented by the synthetic object S as shown, the angle between the object vector V'^*_{NK3} and the camera vector V'^*_{K3} now being smaller than the angle between the zoom vector V_{Z3} and the camera vector V'^*_{K3}, as can be seen in FIG. **4***d*.

As mentioned, the attributes of the synthetic object S may be freely chosen and the object naturally does not need to be a true representation of the natural object, either with regard to size, shape or colour. An ice hockey puck, e.g., may be generated as a highly luminous, pulsing or blinking object in a contrasting colour. Moreover, the size or colour of the

object can be caused to vary in order to indicate to the viewer the apparent distance between him and the natural object, as it appears when viewing a television picture. Furthermore, the synthetic object can be provided with labels or indicators, e.g. of an alphanumerical nature or in the form of shining or blinking arrows or other visual indicators in order to indicate the distance of the object from, e.g., the camera, or also the speed, direction and position of the object. All of this can be introduced into the shown television picture in connection with the synthetic object S and overlaid the natural background in the television picture. The actual generation of the synthetic object and other indicators is performed in the manipulator module shown in FIG. **2**, and may, e.g., take place by means of a not shown video generator of a type which is well known to those skilled in the art.

The detection of the natural object and the distance determination will now be described in more detail.

There are known and described in the art a number of different systems for measuring the distance to an object, e.g. by transmitting from an antenna optical, acoustic or electromagnetic signals which are reflected back to the antenna by the object whose distance has to be determined. The measured time difference between the transmission and receipt of the signals is a direct measure of the distance to the object, since the propagation velocity of the signals in the surrounding medium is assumed to be known with sufficient accuracy, and a time measuring system is employed which provides the desired accuracy in determination of the distance. For example, in U.S. Pat. No. 3,503,680 (Schenkerman) there is disclosed a distance measurement system based on a pulse radar. The technique therein disclosed takes into account the fact that the object whose distance has to be measured can move at a relatively great speed, with the result that instead of transmitting a pulse and then measuring the running time of the pulse between the object and the antenna, a sequence of pulses is used, the receipt of the echo or the return pulse of a transmitted pulse being employed to trigger the transmission of a second pulse. This process is repeated until a predetermined number of echo pulses has been received, and the time taken to receive a predetermined number of echo pulses is proportional to the distance to the object. The method can be employed both with electromagnetic signals and acoustic signals.

GP-PS no. 1,290,915 (Allard & Clark) also discloses a distance measurement system based on pulse radar of a similar nature to that disclosed in the above-mentioned U.S. patent.

Otherwise it is well known in the art to measure the distance to a movable object by means of a so-called CW radar which finds the radial speed of the movable object by means of a detected Doppler shift in the return signal or the echo signal. By employing a phase comparison it will be possible to find the distance to the movable object.

The disadvantage of using distance measurement systems based on detection of a return echo, however, is the many sources of error which can arise, e.g. due to false and spurious echoes and so-called glitter, i.e. reflected noise from ground or sea, and similarly the fact that the natural object concerned may not be suited to return an echo, even though it could conceivably be equipped with radar reflectors or a reflecting surface. In various kinds of sport, such as ice hockey, however, this is assumed to be an unsuitable method.

Instead of using a passive transponder, i.e. a return echo or reflected signals from the natural object, according to the present invention use is preferably made of an active transponder. In this case an active transponder should be understood to refer to a transceiver which is provided in the natural object and which, on detecting a polling signal, itself transmits a response signal. As a rule the transceiver must have its own energy source and a pulse transmitter for generating the response signal, and in this connection an energy source, e.g. in the form of a battery will be a substantial drawback, both because the battery can be damaged and because it will have a limited life. Since the active transponder also has to be mounted in the natural object, it has to be robust and capable of withstanding jolts and shocks as well as relative high accelerations. In this context reference may be made to the stresses to which, for example, a tennis ball, a golf ball or an ice hockey puck will be exposed when they are struck by, e.g., a racket or club.

There is therefore a requirement for the active transponder to be robust, to withstand considerable acceleration stresses and not to require its own energy source, while at the same time being small enough to be inserted in a natural object which at any rate is not larger than an ice hockey puck. A transponder of this kind should also be suitable to be worn by, e.g., individuals without causing them any inconvenience, such as participants in a game or athletes or other people whom it is desirable to record in a television picture by means of a synthetic representation of the person concerned. This will be discussed in more detail later.

A block diagram of a transponder as used according to the invention in the natural object is illustrated in FIG. **5**. The transponder consists of an antenna **5**, an impedance matching network **6** and a pulse transmitter **7**.

As stated, the transponder's pulse transmitter can be implemented as an active unit based on battery operation or as a passive system without a battery. In the present invention, however, an active system without battery is preferably employed which has, as already mentioned, a number of operative advantages and this is preferably implemented by means of acoustic surface wave technique (SAW technique).

The transponder as illustrated in FIG. **5** and used in the present invention is therefore a so-called acoustic surface wave component. Such acoustic surface wave transponders or SAW transponders consist of a crystal plate with an input electrode and one or more output electrodes, as is illustrated and will be described in more detail in connection with FIG. **6**.

An SAW transponder T as illustrated schematically in FIG. **6**, has long been known to those skilled in the art in and consists in principle of a crystal, e.g. of lithium niobate with a surface pattern of metal which constitutes transducers, reflectors, etc. A polling pulse from the position detector D is received by a transducer **8** which is shown in the form of a so-called interdigital transducer. The received electromagnetic energy in the polling pulse is converted in the transducer **8** to an acoustic surface wave which moves along the crystal. At a certain distance from the transducer **8** there are placed a first reflector **9***a* and a second reflector **9***b* respectively. When the acoustic wave strikes the two reflectors **9***a* and **9***b*, reflection waves are created which move back to the transducer **8**. The transducer **8** will convert the two acoustic reflection waves to electromagnetic pulses which constitute the response signal which is transmitter via the transponder's antenna. At the end of the transponder T there may be provided a surface wave absorber **10**. The path of the signal is illustrated schematically in FIGS. **7***a* and **7***b*.

When the transponder T receives an interrogator or polling pulse **11** of length τ_p, as illustrated in FIG. **7***a*, the pulse

transmitter 7, i.e. the transducer **8**, is triggered, and a response signal is transmitted by the antenna after a specific time τ_D. As illustrated in FIG. **7***b*, the response signal consists of two pulses **13***a*, **13***b*, located at a distance T_x apart from each other. For different categories of natural objects the category of the object may be determined by, e.g., measuring the pulse distance T_x in the position detector D which also transmits the polling signal.

In principle this technique is exactly the same as techniques for the use of radar transponders based on SAW technique, since, as is well known, SAW components are used as delay members in RF communication and detection systems. The transponder, which may be in the form of an integrated enclosed chip, can be coded by selecting a pulse distance between two reflection pulses equal to an integral multiple of, e.g., the length τ_p of the polling pulse. The transponder T may, of course, comprise more than the two reflectors **8***a*, **8***b* as illustrated in FIG. **6**, and in this case it can be used to emit the response signal with a large number of different codes. In this way a transponder T based on SAW technique can be employed in detection of the distance to a large number of natural objects N, since the code thus unambiguously identifies which of the natural objects are involved. This may be relevant in cases where the method and the system according to the present invention are intended to monitor a game where several objects are employed simultaneously in the game, such as in golf or during athletics competitions where it is desirable to follow a large number of competitors each of whom is equipped with a transponder. In the case of approximately simultaneous detection of several response signals, in order to achieve an unambiguous detection it may be appropriate to use special detection techniques, e.g. based on correlation between detected, coded reply pulse sequences and prestored code sequences for each individual transponder. A second possibility is to use polling signals at different frequencies and corresponding frequency-tuned transponders. Finally, transponders may be employed with different delays τ_d. In this case the delays must be adapted to the distance range concerned for detection, so that the response signals for the detector in respective unambiguously defined times are relative to the time for the transmission of the polling signal.

FIG. **7***a* illustrates a pulse pattern employed in the position detector D, where polling pulses **11** are transmitted with pulse length τ_p and with a given time interval between the polling pulses corresponding to a desired sampling frequency sequence. The response signal from the transponder T will arrive at the position detector D in the form of the pulse sequence **13***a*, **13***b*, as illustrated in FIG. **7***b*, while in this case the pulse shape **11** represents an echo caused by ground or sea glitter and centred around the real distance to a reflection point at or near the transponder T. However, use of a SAW component as transponder will delay the response signal by a predetermined value τ_d and the reply pulses **13***a*, **13***b* will therefore arrive some time after the glitter pulse **11** and thereby not be masked by it. The distance selected between the reply pulses **13***a*, **13***b* here is τ_x and the delay will be equal to τ_d, the distance from the transducer **7** to the reflector in this case naturally corresponding to a running time of ½ τ_d and in addition the distance between each reflector corresponding to a running time of ½ τ_x. The reply pulse from the transponder T will now arrive at the detector D after an interval $\tau=\tau_a+\tau_d$, wherein τ_a is the running time for an electromagnetic signal from the position detector D to the transponder T and back and τ_d the time delay entered in the transponder. To the period τ_d there will naturally be added further periods τ_x for the reply pulses from each further reflector **9** in the transponder T. What is now required of the system is that the time τ should be able to be measured with an accuracy which is preferably of the order of 10^{-1} m, possibly even less, and this will be within the scope of current technology. Thus the time delay τ_d and the period τ_x must be precisely known, and this can be achieved by a careful calibration of the SAW transponders used. In order to achieve such accuracy, the frequency selected for the polling signal should be at the upper end of the L band or in the S or X band, i.e. it should have a frequency of between circa 1 Mhz and 10 Mhz, or in other words a wavelength of between 30 cm and 3 cm. The clock employed in the signal processor **1** should have a rate which is adapted to the frequency of the polling signal and the response signal. Thus with present day technology distance detections can be obtained with an accuracy of the order of 10^{-1} m or less within the distances which will normally occur when using the method and the system according to the invention, i.e. preferably in sports arenas or the like.

In order to test and calibrate the system according to the present invention, in the corner of the area A as illustrated in FIG. **1** there can be provided permanently mounted and accurately calibrated transponders T_K in fixed positions and coded in order to emit unambiguous identifying response signals. These are used to calibrate the system and the position detectors D. Transponders are also preferably provided both in the position detectors and the cameras. When mobile cameras such as "Handycam" and "Steadycam" are used, it will be possible to determine the camera positions by means of the position detectors D.

It will also be seen that by using the SAW transponders as preferred in the present invention, it will be possible to place these without difficulty in most natural objects N which it will be appropriate to follow and display in connection with a television broadcast, whether it be a football or an ice hockey puck. As mentioned, SAW transponders are very robust and capable of withstanding substantial acceleration stresses, nor do they require their own power source, while at the same time they can be designed with extremely small dimensions, measuring, for example, only a few millimeters. They may, e.g., be enclosed in a shock-absorbing material fitted inside the natural object, but otherwise no special measures are necessary to protect them from damage. At the same time it will be extremely simple to replace them if they really should be destroyed. However, they are also so inexpensive to manufacture that it will be just as easy to replace the natural object with another with a similar SAW transponder. When used in connection with other natural objects than, e.g., footballs, ice hockey pucks etc., for example worn on a person, the transponders may be designed in the form of an enclosed chip which is attached to the person and worn during the period concerned. Since the SAW transponder can be arranged to emit an unambiguous coded reply signal, the person wearing the transponder chip will also be unambiguously identifiable.

The system according to the invention may comprise a number of position modules M which are assigned to one or more respective television cameras K, each position module being arranged to cover a predefined area in the x,y,z co-ordinate system. This implies that the use of the method and the system according to the present invention is not restricted to only a well-defined area such as a field for ball games or an ice hockey rink and the like, but can be employed to cover areas of arbitrary shape and size, such as, e.g., cross-country skiing courses, Alpine skiing slopes and the like. Nor are the method and the system according to the

present invention only restricted to sporting arrangements, but they can be used to cover events within large and relatively freely defined areas. Such areas can be divided into several partial areas, and the system does not necessarily have to cover each partial area or the entire area, but the use of the system may be restricted to selected partial areas.

An example of a set-up of the system according to the present invention for use, e.g., in a ski run or Alpine skiing slope is illustrated in FIG. **8**. Here, the area A is divided into three partial areas A_1, A_2, A_3. To each partial area A_1, A_2, A_3 there are assigned respective position modules M_1, M_2, M_3. The partial area A_1 is covered, e.g., by a position module M_1 with 3 position detectors D_1, D_2, D_3 which are interconnected via the signal line L_1 and thereby connected to a data processing device Q_1. The data processing device Q_1 is connected via a local data bus B_1 with the cameras K_1, K_2 via their respective regulator modules R_1, R_2. Typical picture fields for the cameras K_1, K_2 are indicated by broken lines and similarly are surrounded by the main lobe of the antenna in one of the position detectors D_3 indicated by broken lines m_{D3}. The data processing device Q_1 is connected to a production unit P via a global data bus B_G. The same applies to position modules and cameras which are assigned to the remaining partial areas A_2, A_3. Moreover, in each of the partial areas A_1, A_2, A_3 transponders T_K are provided for calibrating in fixed positions, such as at the edge of each partial area. Furthermore, the global data bus B_G may be connected to the timekeeping system, indicated in FIG. **8** as CL_1 at "START" and CL_2 at "FINISH" respectively.

In FIG. **8** two natural objects N_1, N_2 are illustrated, the first natural object N_1 being substantially located in the third partial area A_3, and the second natural object N_2 in the partial area A_1. Each of the objects is shown in two different positions x,y,z; x',y',z' at the times t and t' respectively, where it should be understood that positions and times do not need to be identical for the two objects N_1, N_2. The path of each of the objects N_1, N_2 between the first and the second position is indicated by a broken line. The distances from the position detectors D to the objects N_1, N_2 and their positions are determined as described earlier in connection with FIG. 1.

Since the position modules' polling signal has a high frequency and directive antennas are employed, it will be understood that the signals move substantially in a straight line. In other words they can be stopped by obstacles in the terrain and the like. By dividing up the area A into sub-areas A_1, A_2, A_3 which are assigned to respective subsystems of position modules D and cameras K, the entire area A will still be able to be covered by using the method and the system according to the present invention. The selected positions of the position modules D and the cameras K must therefore take topographical and other conditions into consideration.

In the area A obstacles may be encountered which prevent the objects N from being shown in the cameras' picture field. This may, e.g., be vegetation, groups of people and the like, but it will not obstruct the free passage of the detector and transponder signals employed. This means that the position of the natural object N can still be indicated in the cameras' picture field, even though the object N at the time concerned happens to be covered by obstacles which hinder visual contact. In this case the natural object N may naturally be represented by a synthetic object S in the correct position X,Y in a television picture. Such conditions can easily arise, e.g., in reports from cross-country skiing, where the skiers will be invisible due to the vegetation, even though the camera is located in a position which should in theory cover the section of the cross-country course concerned. Thus by means of the design illustrated in FIG. **8**, the methods and the system according to the present invention permits a complete coverage to be obtained with indication of the position of the natural objects N, in the case of sporting events or naturally also the position of the competitors, even though they are, e.g., masked by vegetation and the like in the cameras's picture field. Neither reporters nor viewers need, therefore, to be left to guess where an anticipated favourite is located at that moment.

As mentioned above, by means of a method according to the invention a synthetic track can be generated in a television picture, the synthetic track thus being intended to represent the path of a natural object N in the television picture during a given period θ. The path of the natural object N can be calculated, as already mentioned, on the basis of detected positions x,y,z in a preselected co-ordinate system at the time t. The time t will thus lie within a period θ. The detected positions x,y,z are converted to an X,Y position in the picture plane of a relevant television camera at the time t. The synthetic track in the television picture is created as the connecting line between all X,Y positions for the natural object in the picture planes of the television pictures which are recorded sequentially during the period θ. The synthetic track may now, e.g., be displayed in a still picture which need not be recorded during the period θ, or it can be continuously updated and generated for each individual picture which is recorded during the period θ, thus creating the synthetic track cinematographically. Like the synthetic object S the synthetic track can be created with given, possibly similar attributes with regard to size, shape and colour. It may preferably be shown, e.g., as a coloured line in a contrasting colour and with indicators for direction of movement and possibly also the speed of the natural object in the path which corresponds to the synthetic track.

An example of generation of a synthetic track for a natural object N is illustrated in FIGS. **9***a*, **9***b* and **9***c*. FIG. **9***a* shows a path a where the natural object moves from positions p_0 to p_3 during the period θ. FIG. **9***a* illustrates this on the projection of the path A in an x,y plane. The path of the object N during the period θ is covered by the camera K and naturally recorded as a sequence of individual pictures by the cameras K. If camera K has the same setting during the period θ, the picture field, e.g., of the camera K in the picture plane I_K will show a section A' of the area A, as illustrated in FIG. **9***b*. Here the natural object N is represented by a synthetic object S shown in the relevant positions p_0, . . . and with the projection of the natural object's path projected in the picture plane I_K as a synthetic track between the various positions p_0, . . . for the synthetic object S as shown in the figure. If, e.g., it is a television report from a football match which is being shown, N will, naturally, usually be the football and the synthetic track will represent the ball's path from the position p_0 to the position p_3, in three dimensions, but projected into the picture plane I_K. $I_K(t)$ may be the final picture in the sequence which was recorded during the period T, and in this case the track shown for the synthetic object S is the path from the beginning of the period θ up to the last recorded picture during θ. It is, of course, not essential that the track should only be shown continuously in the recorded pictures during the period θ, since the synthetic track can be inserted in a freely selected still picture or in a television picture which is recorded at a time outside the period θ.

Nor is it a condition that the synthetic track should only be shown in natural television pictures, and, as illustrated in

FIG. 9c, the actual television picture may be a synthetic television picture $I_K(S)$ produced, e.g., by a video generator, not necessarily with a view to representing the camera perspective, but it may be some kind of graphic representation of the area A. FIG. 9c shows a graphic representation A_S of the field A reproduced in an X,Y plane in the form of a synthetic television picture. The movement of the natural object N is then shown projected in the X,Y plane as the movement of the synthetic object S from the position p_0 to position p_3. A person skilled in the art will easily see that it will be possible to use different perspectives, such as a side view, or also possibilities of manipulating the picture with the synthetic object and the synthetic track by means of various video graphic methods. Nor is there any reason why, on the basis of the data acquired for the position and the movement of the natural object N during the course of the game, the path of the natural object should not be presented during the course of a game or during a selected period, thus aiding the analysis of the game. The technique may also be employed by meeting officials and referees in order to judge situations which otherwise would be difficult to assess if the judgement alone were to be based on momentary impressions during the course of the game.

As mentioned, there is no reason why the system should not detect and monitor a number of natural objects $N_1, \ldots N_n$, the natural objects being unambiguously defined by the use of transponders which emit coded reply signals which unambiguously identify the natural object concerned. FIG. 11a refers to a situation which could arise in an area as illustrated in FIG. 8. Two natural objects N have moved through the partial area A_3, but during different periods. The first natural object N_1, e.g. has moved from the position p_0 to the position p_3 during the period θ, while the natural object has moved from the position p'_0 to the position p'_3 during the period θ'. The paths of the natural objects are indicated as broken lines in FIG. 9a. In FIG. 9b the detected and calculated paths of the natural objects N_1, N_2 are represented by the corresponding synthetic objects S_1, S_2 and converted to synthetic tracks for the objects S_1, S_2, being illustrated simultaneously in one and the same picture $I_K(t)$ at the time t. Data for times and speeds which form the basis for a comparison between the movement of the objects N_1, N_2, for example Alpine skiers, can be introduced into the picture. The X,Y projection of the partial area A_3 in the picture plane I_K at the time T will appear as the picture $I_k(t)$ illustrated in FIG. 11b and choice of line and skiing style can, e.g. be directly compared.

It will be obvious to a person skilled in the art that it is possible to create a real time reproduction, i.e. the development, e.g., of a game or race can be followed in simulated real time by means of synthetic objects and synthetic tracks in the television picture. This may occur, e.g. in connection with a playback, but when using the method and the system according to the present invention, the producer of the television broadcast has a great deal of freedom to manipulate objects and information as they are displayed either in natural or synthetic television pictures. It will be possible, e.g., to combine synthetic tracks and synthetic objects with various forms of animation graphics, if so desired.

As shown in FIG. 1 and FIG. 8, transponders $T_{K'}$ are installed in various fixed positions in the area A for calibration of the system. As mentioned above, transponders may also be installed both in the position detectors D and in the cameras K. In the latter case movable or mobile cameras can be employed, i.e. cameras which are not mounted in a fixed position, and may be of the type "Handycam" or "Steadycam". These cameras must also naturally be connected to data processing devices Q via data buses B, or local data buses, in which case they may expediently be based on a wireless connection.

The method and the system according to the present invention are not necessarily limited to sports reports, but may be applied in a number of other kinds of television transmissions. It will also be possible to employ the method and the system in transmissions which are not restricted to fixed and specific areas, e.g. in connection with nature programs on television. If the natural object is located beyond the range of the position detectors, but within the field of view of a camera, the position of the natural object must be determined by other means. In this case the natural object may be equipped with a GPS (Global Positioning System) receiver for determination of the position, this being remotely read at the production location. Similarly, the position of a mobile camera, which is also located beyond the range of the position detectors, is determined by means of GPS and transferred to the production location. Positions and paths for the natural object can then be calculated according to the method in the present invention, and the natural object is represented by a synthetic object which is inserted in the correct position in a television picture recorded by a camera where the natural object is located in the picture field. An example of such an application in nature reports may be, e.g., animals which are equipped with radio transmitters and GPS receivers and are followed, e.g., by a helicopter-borne "Steadycam". Even though the natural object may be hidden by obstacles which prevent it from being viewed directly in the television picture, its position and movement can still be indicated by a synthetic object or a synthetic track which is inserted in the television picture. In such cases the positioning accuracy is not particularly critical and may well amount to several meters, or possibly several tens of meters. Such a positioning accuracy lies within the range of possibility when using GPS at its highest time resolution.

As stated, in principle the natural objects, which have to be detected and displayed represented as synthetic objects and possibly represented in motion as synthetic tracks, may be practically anything at all. In sports competitions, e.g., the competitors may also be equipped with transponders and their positions and movement are detected and displayed. Since the transponder's reply signal may be in the form of an unambiguous code, the identification of the transponder will also be unambiguous and the necessary identification information can naturally be shown in the television picture in some way or other, such as by showing the portrait of the competitor overlaid a part of the television picture.

The use of the method and the system according to the present invention in television broadcasts and television reports will be capable of being implemented in other circumstances than those herein described, and it should also be understood that the methods and the system according to the present invention for displaying and representing the natural object and its movement in the form of a synthetic object in a television picture and a synthetic track for the synthetic object can be realised in a number of different variants and varying attributes which are not expressly indicated here, but which nevertheless will be obvious to those skilled in the art and which fall within the scope of the present invention.

What is claimed is:

1. A method for manipulation of at least one movable, natural object in a natural television picture, wherein the television picture is generated by one or more television

cameras, characterized by detecting the distance between the object and at least 2 fixed basic positions in a preselected x,y,z co-ordinate system at a time t, each basic position corresponding to a known position of a detector, determining an x,y,z co-ordinate for the object in the preselected x,y,z co-ordinate system at the time t, determining the distance between the camera's lens centre and the object at the time t as an object vector in the preselected co-ordinate system, determining the television camera's optical axis in the preselected co-ordinate system at the time t as a camera vector in the preselected co-ordinate system, determining a line from the television camera's lens centre to the point of intersection between the edge of the generated television picture and the plane formed between the object vector and the camera vector at the time t as a zoom vector, the object vector being located between the camera vector and the zoom vector when the object is visible in the television picture at the time t, and when the object is not visible in the television picture at the time t, the zoom vector is located between the camera vector and the object vector, and determining an X,Y position of the object referred to the television camera's picture plane and the camera vector on the basis of the object vector and the camera vector at the time t, and if the object vector is located between the camera vector and the zoom vector, to insert a synthetic object in the X,Y position in the television picture at the time t, the synthetic object constituting a representation of the natural object recorded by the camera at the time t, or, if the zoom vector is located between the camera vector and the object vector at the time t, to insert a symbol in the television picture, the symbol indicating the location of the X,Y position of the natural object outside the edge of the picture referred to the television camera's picture plane and the camera vector.

2. A method according to claim **1**, characterized in that the distance between the object and the basic positions, together with the object's x,y,z co-ordinate are determined by trilateration.

3. A method according to claim **1**, characterized in that there are employed 2 fixed basic positions in the preselected x,y,z co-ordinate system if the natural object is located for every value of t in a plane defined by the fact that one of the co-ordinates x,y,z of the natural object is equal to zero, or that at least 4 fixed basic positions are employed in the preselected x,y,z co-ordinate system if the natural object is located for at least one or some values of t in a space defined by the fact that none of the co-ordinates x,y,z is equal to 0, thus obtaining an unambiguous determination of the natural object's x,y,z co-ordinate at time t.

4. A method according to claim **1**, characterized in that the synthetic object is either created with given attributes for size, shape and colour, or that the synthetic object's attributes are freely selected, or that the synthetic object's attributes are chosen within preselected limits, or that the synthetic object's attributes are determined on the basis of respective reference values for the attributes.

5. A method according to claim **4**, wherein the synthetic object's attributes are determined on the basis of respective reference values for the attributes, characterized in that the synthetic object's attributes are manipulated automatically on the basis of setting values for the television camera such as camera angle and zoom setting and on the basis of the colour of the background of the natural object as shown in the television picture.

6. A method according to claim **1**, characterized in that the synthetic object is assigned alphanumerical or symbolic signs which indicate the value of one or more parameters of the represented natural object, and the parameters may be constants which identify the natural object or dynamic values such as the object's momentary x,y,z position, distance to a freely selected fixed point, course and speed.

7. A method according to claim **1**, characterized in that the settings of the television camera such as camera angle and zoom setting are controlled in approximate real time on the basis of the calculated X,Y position of the natural object at the time t and referred to the camera's picture plane and the camera vector, with the result that the natural object is located within the edge of the picture of the generated television picture at any time t, the control being performed via a control system assigned to the camera.

8. A method according to claim **7**, wherein more than one camera is employed, characterized in that a choice is made via the control system as to which camera should be employed to generate the television picture which is shown at time t.

9. A method for generating at least one synthetic track in a television picture, wherein the synthetic track represents the path of a movable, natural object in a natural television picture during a given period θ, and wherein a method is employed for manipulating the movable, natural object in the television picture as indicated in claim **1**, characterized by calculating the path of the natural object on the basis of detected positions x,y,z for the a natural object in the preselected x,y,z co-ordinate system at the time t, where $t \epsilon \theta$, converting the detected positions at the time t to an X,Y position in the television camera's picture plane at the time t, and generating the synthetic track in the television picture as the connecting line between all X,Y positions of the natural object in the picture planes of the natural television pictures which are recorded sequentially during the period θ.

10. A method according to claim **9**, characterized in that the synthetic track is generated and updated continuously for each individual picture which is recorded during the period θ.

11. A method according to claim **10**, characterized in that the synthetic track is generated and displayed as the path of the natural object during the period θ in a freely selected television picture which forms a background for the natural object, the X,Y positions being scaled for each time $t \epsilon \theta$ and assigned to the picture plane of the freely selected television picture.

12. A method according to claim **11**, characterized in that the freely selected television picture is a natural television picture, the freely selected television picture forming part of the sequence of the natural television pictures which are recorded during the period θ, or that the freely selected television picture is a synthetic television picture.

13. A method according to claim **9**, characterized in that the X,Y positions for one or more of the times t are indicated on the synthetic track, the indication of the X,Y position in the synthetic track being formed as a synthetic object with given attributes for size, shape and colour, and in such a manner that the synthetic object constitutes a representation of the natural object recorded by the camera at the time $t \epsilon \theta$.

14. A method according to claim **13**, characterized in that the indication of the X,Y positions or the synthetic object is assigned alphanumerical or symbolic signs which indicate the value or one or more parameters for the represented natural object, and the parameters may be constants which identify the natural object or dynamic values such as the object's momentary x,y,z position, distance from a freely selected fixed point, course and speed at the time $t \epsilon \theta$.

15. A system for implementing the method for manipulation of at least one movable, natural object (N) in a natural

television picture, wherein the television picture is generated by one or more television cameras (K), together with implementation of the method for generating a synthetic track in a television picture, wherein the synthetic track represents the path of a movable, natural object in the television picture during a given period θ, and wherein a method is employed for manipulating the movable, natural object in the television picture, characterized in that the system comprises a transponder (T) provided in the natural object (N) and arranged to react to an optical, acoustic or electromagnetic signal received by the transponder with transmission of a response signal, at least one position module (M) with at least 2 position detectors (D) for transmitting optical, acoustic or electromagnetic signals and receiving response signals from the transponder (T) and provided in respective basic positions in a preselected x,y,z co-ordinate system, together with a signal processor **(1)** arranged to determine the distance between a position detector (D) and the object (N) at a time t, a computing module **(2)** connected with the signal process **(1)** and arranged to calculate the x,y,z co-ordinates for the object (N) in the preselected co-ordinate system at the time t and on the basis of the calculated x,y,z co-ordinates for a number of times t to calculate a path for the object (N), together with an object vector (V_N) given by the distance between the camera's (K) lens centre and the object (N) at the time t, a camera vector (V_K) given by the camera's (K) optical axis at the time t and a zoom vector (V_z) between the camera's lens centre and the point of intersection (Z) between the edge of the picture and the plane formed between the object vector (V_N) and the camera vector (V_K) at the time t, the object vector (V_N) being either located between the camera vector (V_K) and the zoom vector (V_Z) or the zoom vector (V_Z) between the camera vector (V_K) and the object vector (V_N), a camera control system **(3)** connected with the computing module **(2)** and arranged to detect or generate values for the camera settings, and a manipulator module **(4)** connected with the camera control system **(3)** and the computing module **(2)** arranged to a) create a synthetic object (S) in an X,Y position for the natural object (N) in the recorded television picture at the time t, the synthetic object)S) constituting a representation of the natural object (N) recorded by the camera at the time t or b) create a symbol n the television picture, the symbol indicating the X,Y position for the natural object outside the edge of the picture at the time t, c) generate and select attributes for the synthetic object (S), or d) generate at the time t a synthetic track in a recorded or generated television picture, the synthetic track representing the path for the natural object (N) during a period θ before or up to the time t.

16. A system according to claim **15**, characterized in that the system comprises a number of position modules (M) each of which is assigned to one or more respective television cameras (K), each position module (M) being arranged to cover a predefined area in the x,y,z co-ordinate system.

17. A system according to claim **15**, characterized in that the position detector (D) comprises a microwave transceiver and an antenna (II) for transmission and receipt of microwave signals, and that there is further provided a transponder T in each of the position detectors (D) and/or in each of the cameras (K) respectively.

18. A system according to claim **17**, wherein each said position module comprises at least 4 position detectors (D1, . . . D4) for unambiguous determination of the x,y,z co-ordinates for the object (N) at the time t.

19. A system according to claim **15**, characterized in that the transponder (T) is either a passive transponder, or an active transponder, the active transponder being a surface wave component (SAW component), and that the response signal from the active transponder (T) in each case constitutes a code which unambiguously identifies the transponder by delaying the response signal from the active transponder (T) by a predetermined value τ_d in relation to the time of receipt of a signal which causes the response signal to be transmitted form the transponder.

20. A system according to claim **15**, characterized in that the camera control system **(3)** comprises a control loop for automatic control of camera settings in approximate real time, the camera settings being influenced via a regulator module (R) provided on the camera (K) which module further comprises sensors for detection of the camera settings, and/or that the manipulator module **(4)** comprises a device for automatic generation of attributes for the synthetic object.

* * * * *

US005554983A

United States Patent [19]

Kitamura et al.

[11] **Patent Number: 5,554,983**

[45] **Date of Patent: Sep. 10, 1996**

[54] **OBJECT RECOGNITION SYSTEM AND ABNORMALITY DETECTION SYSTEM USING IMAGE PROCESSING**

[75] Inventors: **Tadaaki Kitamura**, Ibaraki-ken; **Yoshiki Kobayashi**, Hitachi; **Kunio Nakanishi**, Hitachi; **Masakazu Yahiro**, Hitachi; **Yoshiyuki Satoh**, Hitachi; **Toshiro Shibata**, Urawa; **Takeshi Horie**, Kashiwa; **Katsuyuki Yamamoto**, Matsudo; **Masao Takatoo**; **Haruki Inoue**, both of Katsuta; **Kazuyoshi Asada**, Hitachi, all of Japan

[73] Assignee: **Hitachi, Ltd.**, Tokyo, Japan

[21] Appl. No.: **51,692**

[22] Filed: **Apr. 23, 1993**

[30] **Foreign Application Priority Data**

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Jul. 13, 1992	[JP]	Japan	4-185235
Aug. 27, 1992	[JP]	Japan	4-228751

[51] **Int. Cl.^{6}** **G08G 1/017**

[52] **U.S. Cl.** **340/937**; 340/905; 348/135; 348/149; 382/209

[58] **Field of Search** 340/905, 937; 382/30, 31; 348/135, 149

[56] **References Cited**

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Primary Examiner—John K. Peng
Assistant Examiner—Daryl C. Pope
Attorney, Agent, or Firm—Antonelli, Terry, Stout & Kraus

[57] **ABSTRACT**

An object recognition system using the image processing in which an area having a unique feature is extracted from an input image of an object, the unique image is registered in a shade template memory circuit as a shade template, the input image is searched for an image similar to the shade template registered by a shade pattern matching circuit, the position of an object is determined for each template, the speed and direction of movement of the object is determined from the positional information, and the results thereof are integrated by a separation/integration circuit, thereby recognizing the whole of the moving object.

24 Claims, 29 Drawing Sheets

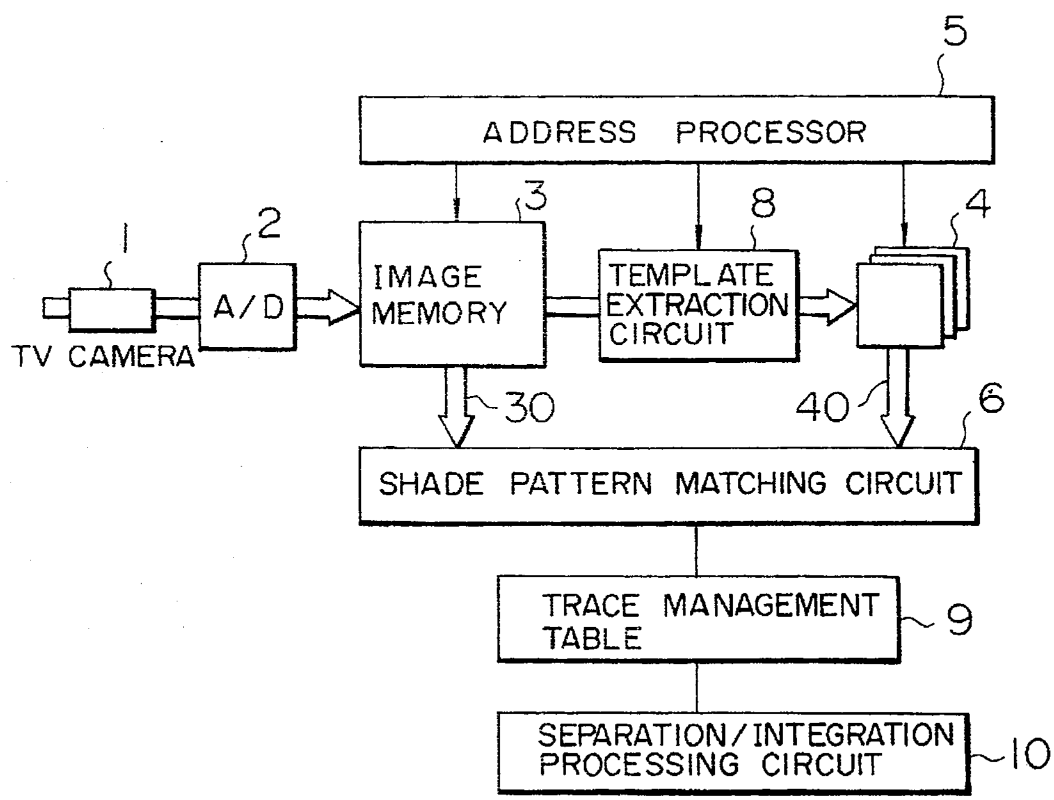


FIG. 1

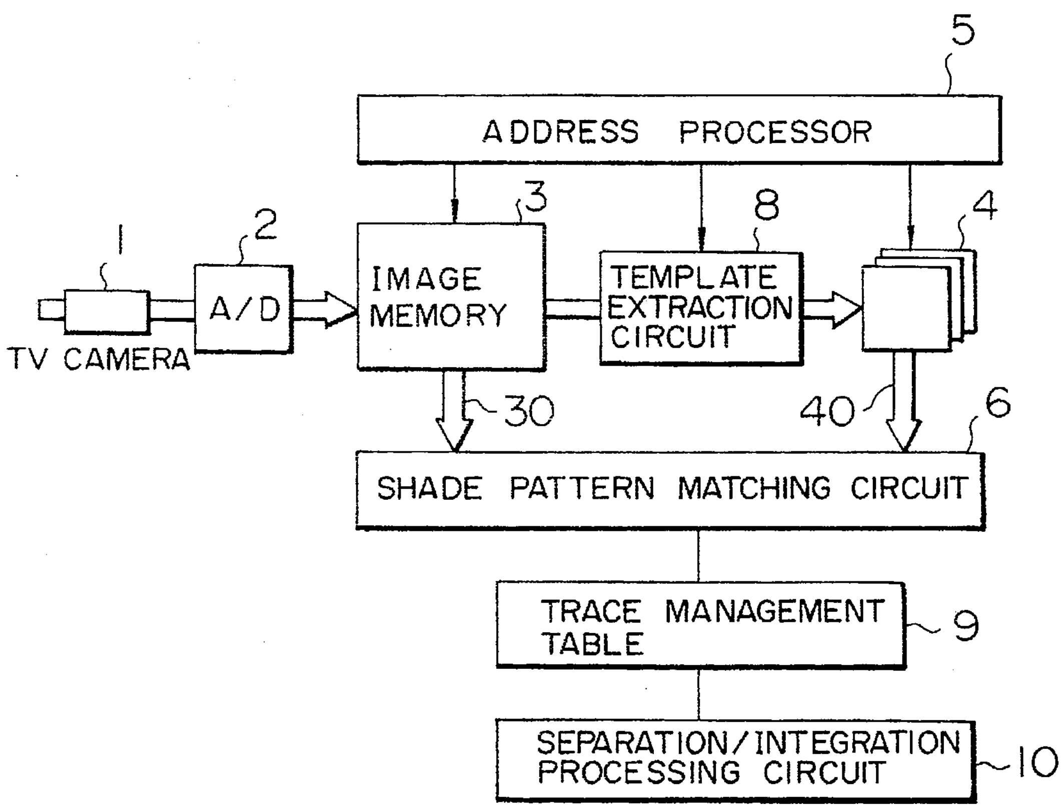

5
ADDRESS PROCESSOR
3
8
4
1
2
A/D
IMAGE MEMORY
TEMPLATE EXTRACTION CIRCUIT
TV CAMERA
30
40
6
SHADE PATTERN MATCHING CIRCUIT
TRACE MANAGEMENT TABLE
9
SEPARATION/INTEGRATION PROCESSING CIRCUIT
10

FIG.2A

INPUT IMAGE f(t)

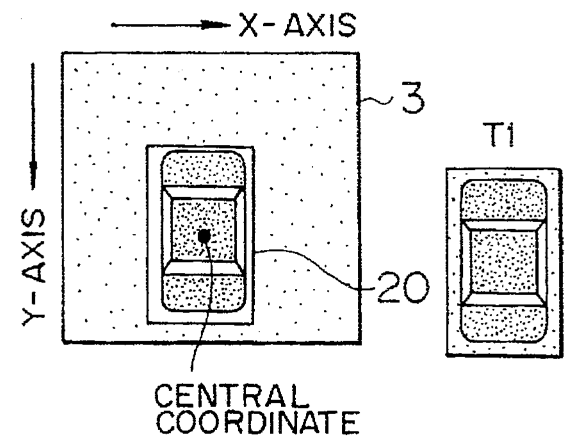


FIG.2B

INPUT IMAGE f(t+dt)

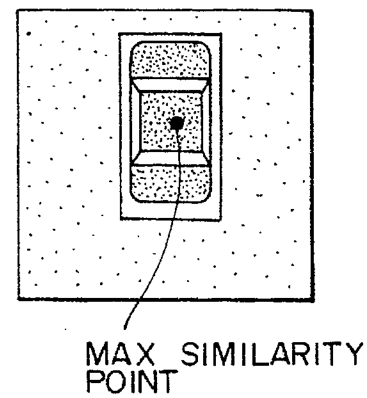


FIG.3A

INPUT IMAGE f(t)

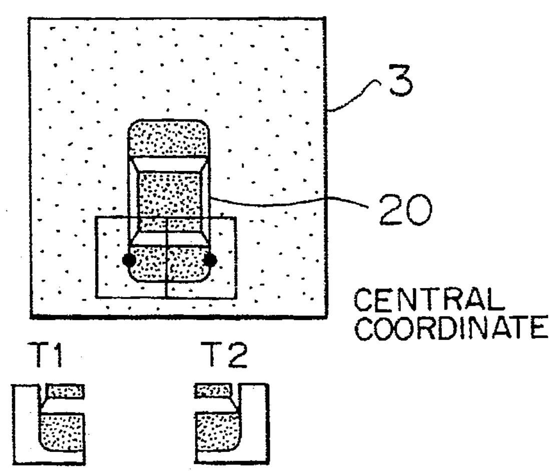


FIG.3B

INPUT IMAGE f(t+dt)

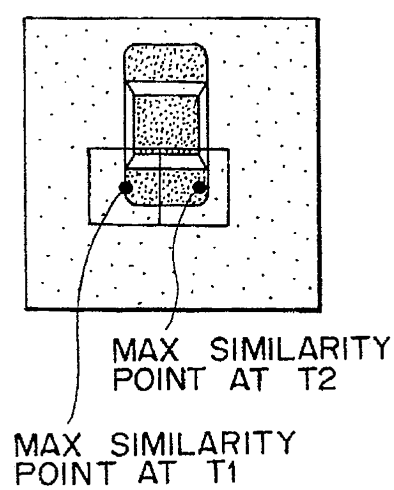


FIG. 4

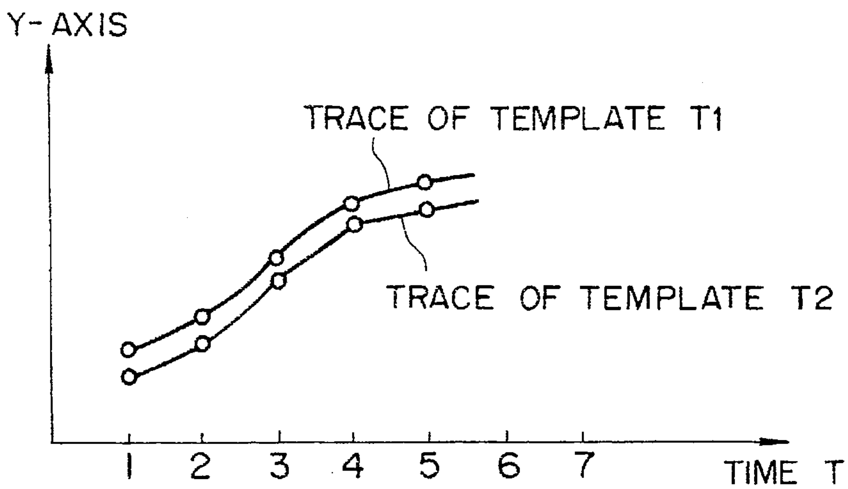

Y-AXIS
TRACE OF TEMPLATE T1
TRACE OF TEMPLATE T2
1 2 3 4 5 6 7
TIME T

FIG. 5

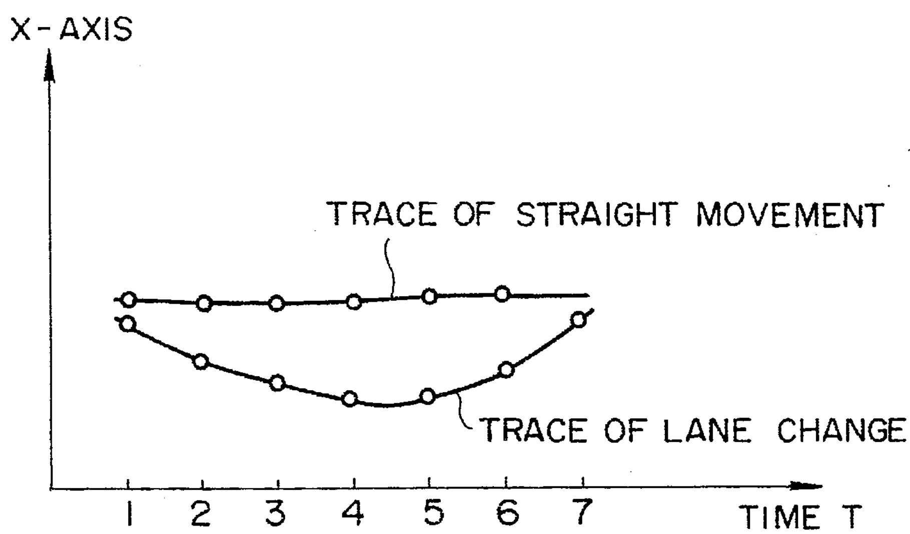

X-AXIS
TRACE OF STRAIGHT MOVEMENT
TRACE OF LANE CHANGE
1 2 3 4 5 6 7
TIME T

FIG. 6

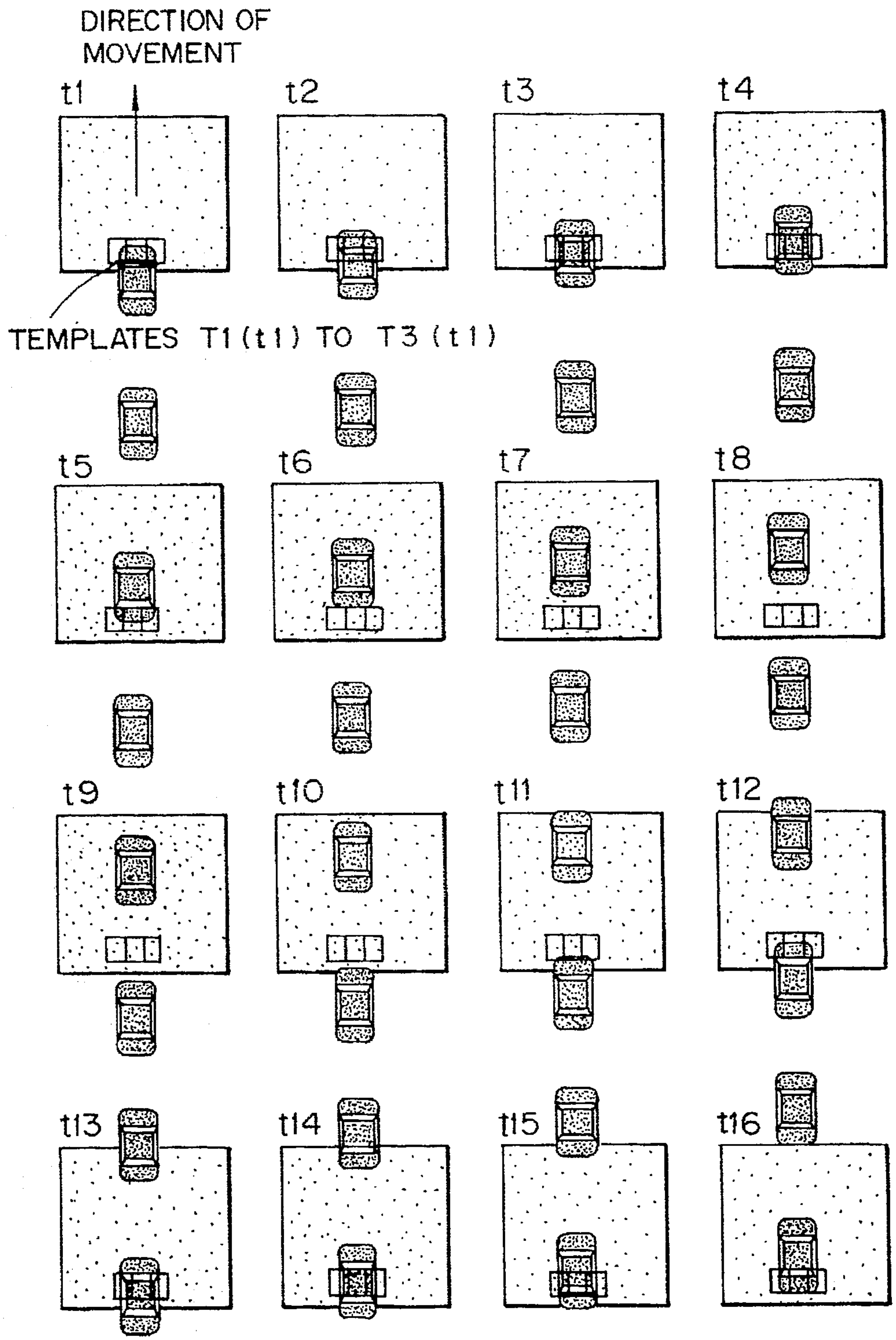

DIRECTION OF MOVEMENT
t1
t2
t3
t4
TEMPLATES T1 (t1) TO T3 (t1)
t5
t6
t7
t8
t9
t10
t11
t12
t13
t14
t15
t16

FIG. 7

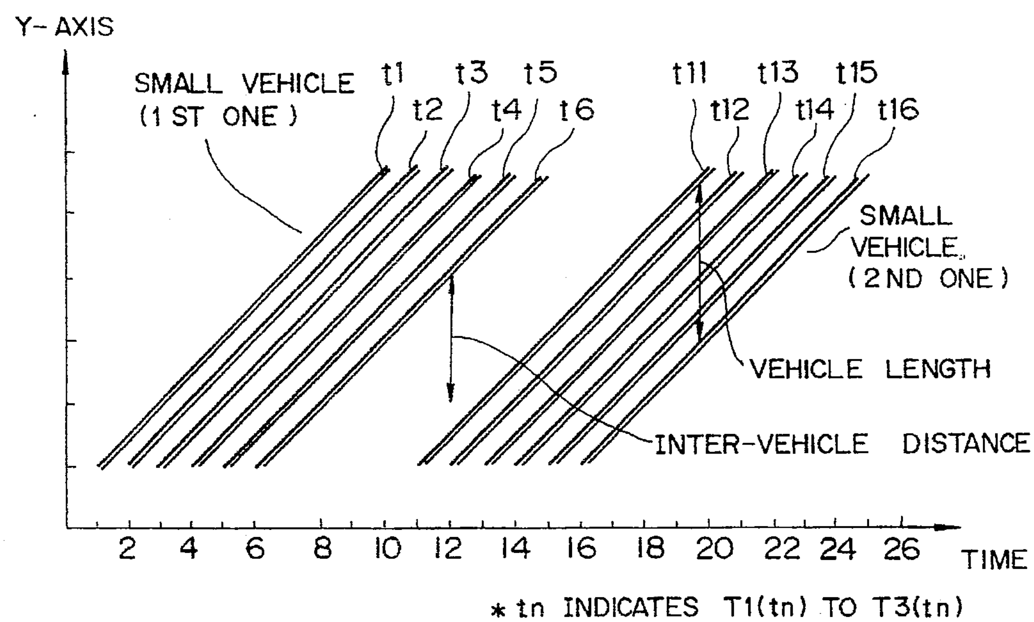
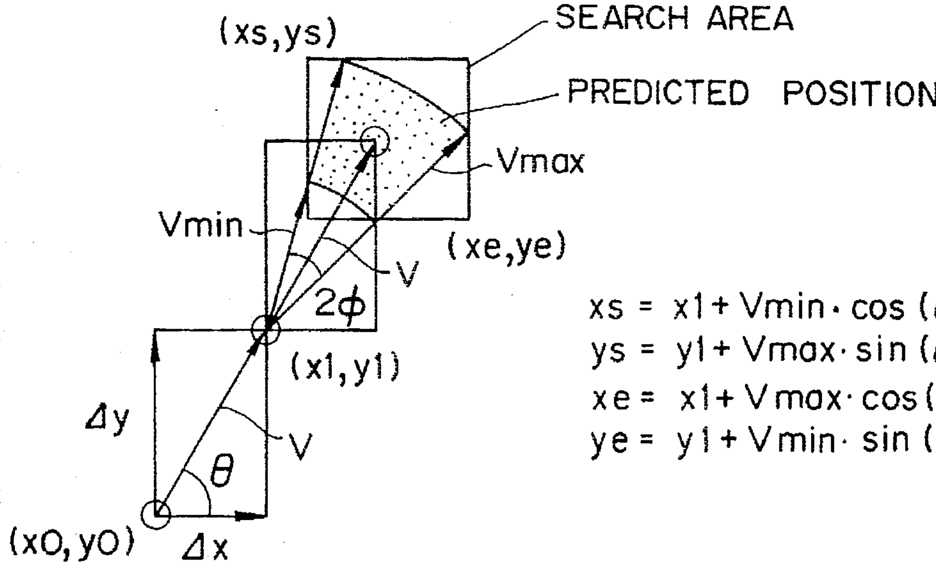

Y- AXIS
SMALL VEHICLE
(1 ST ONE)
t1
t2
t3
t4
t5
t6
t11
t12
t13
t14
t15
t16
SMALL
VEHICLE
(2ND ONE)
VEHICLE LENGTH
INTER-VEHICLE DISTANCE
2 4 6 8 10 12 14 16 18 20 22 24 26
TIME
* tn INDICATES T1(tn) TO T3(tn)

FIG. 8



$$xs = x1 + Vmin \cdot \cos(\theta + \phi)$$
$$ys = y1 + Vmax \cdot \sin(\theta + \phi)$$
$$xe = x1 + Vmax \cdot \cos(\theta + \phi)$$
$$ye = y1 + Vmin \cdot \sin(\theta + \phi)$$

FIG. 9

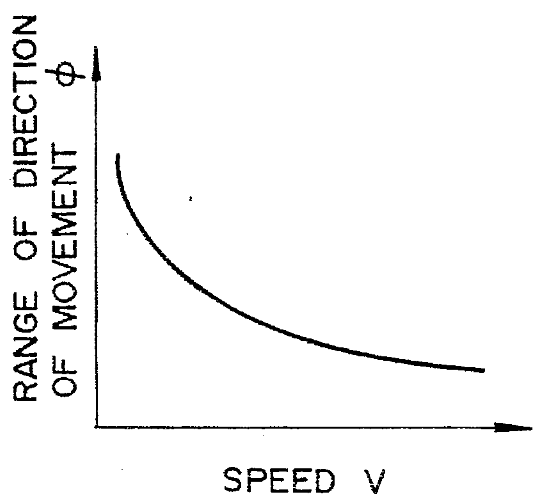
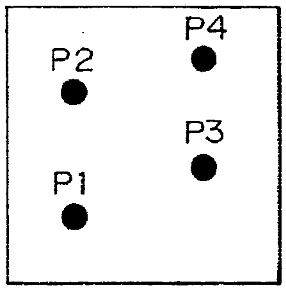
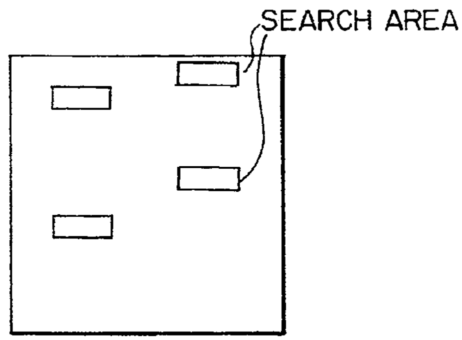


FIG. 10A



TIME t

FIG. 10B



TIME t + Δt

FIG. 11

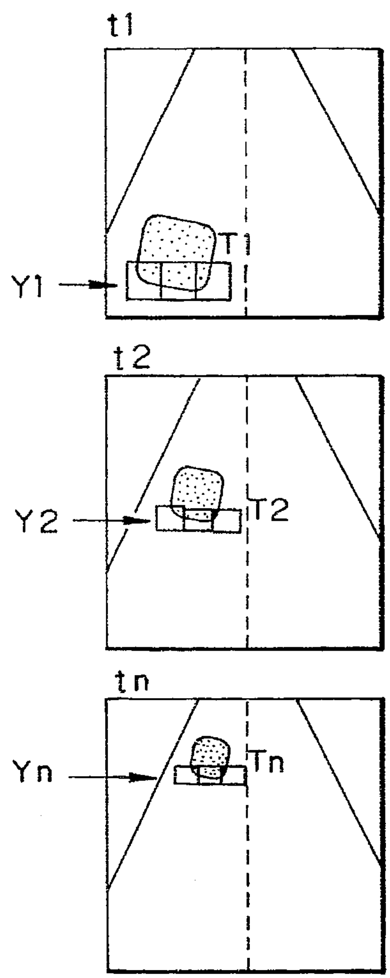


FIG. 12

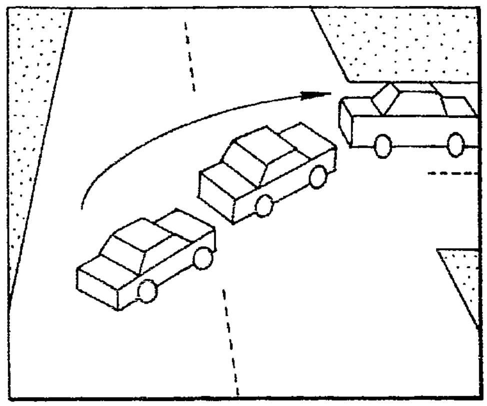


FIG. 13

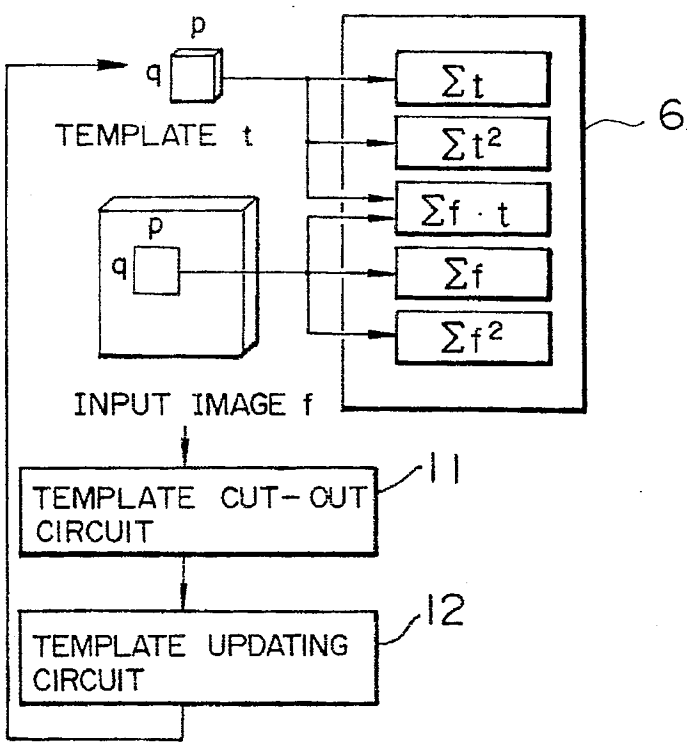

p
q
TEMPLATE t
p
q
INPUT IMAGE f
Σt
Σt^2
$\Sigma f \cdot t$
Σf
Σf^2
6
TEMPLATE CUT-OUT CIRCUIT
11
TEMPLATE UPDATING CIRCUIT
12

FIG. 14A

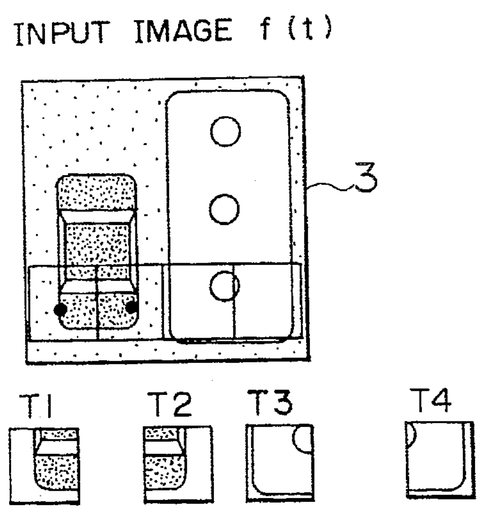


FIG. 14B

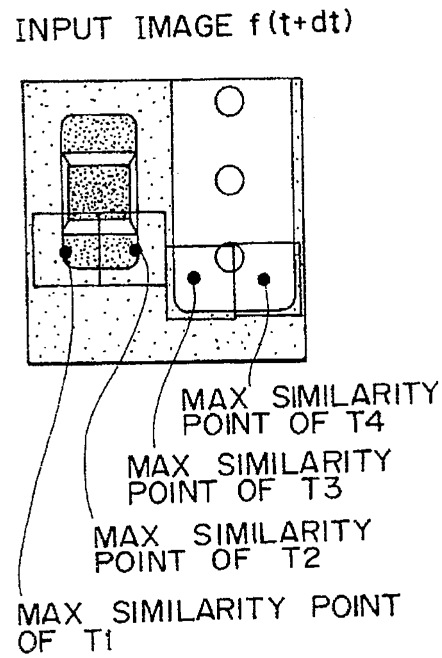


FIG. 15

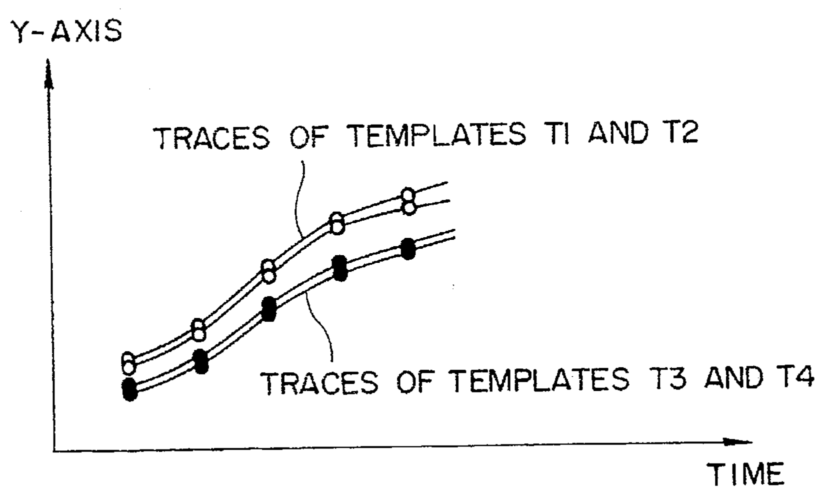


FIG. 16

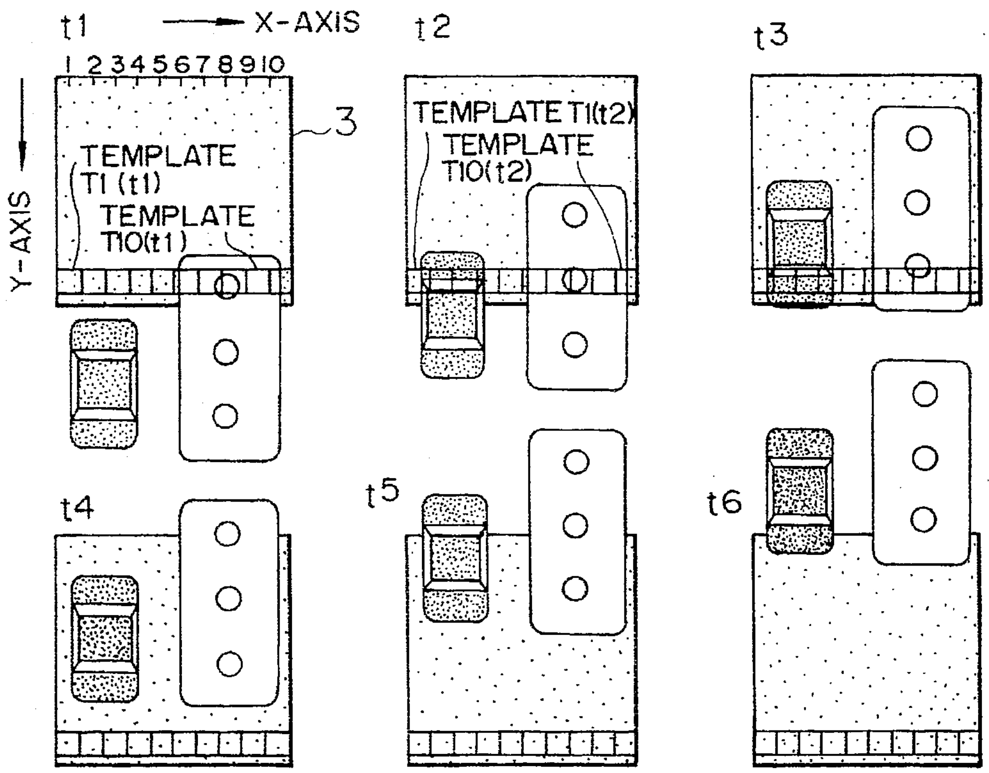

t1
X-AXIS
Y-AXIS
1 2 3 4 5 6 7 8 9 10
3
TEMPLATE
T1 (t1)
TEMPLATE
T10(t1)
t2
TEMPLATE T1(t2)
TEMPLATE
T10(t2)
t3
t4
t5
t6

FIG. 17

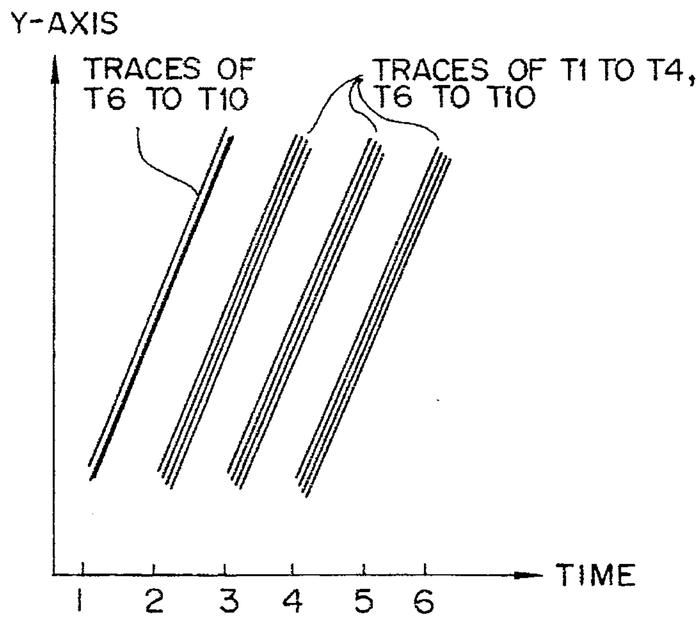

Y-AXIS
TRACES OF T6 TO T10
TRACES OF T1 TO T4, T6 TO T10
1 2 3 4 5 6
TIME

FIG. 18

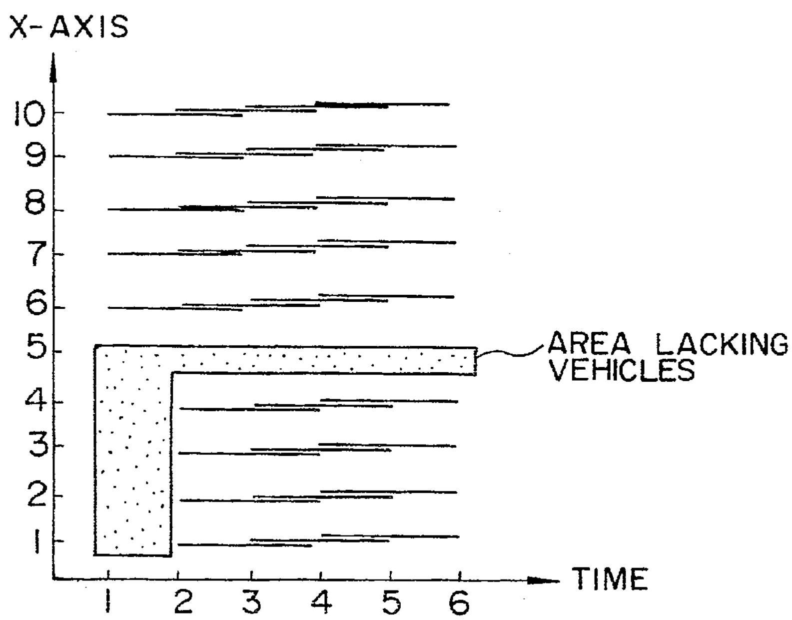

X-AXIS
10
9
8
7
6
5
4
3
2
1
AREA LACKING VEHICLES
1 2 3 4 5 6
TIME

FIG. 19A

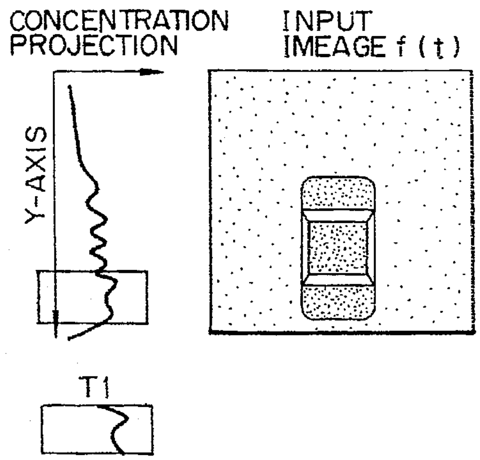


FIG. 19B

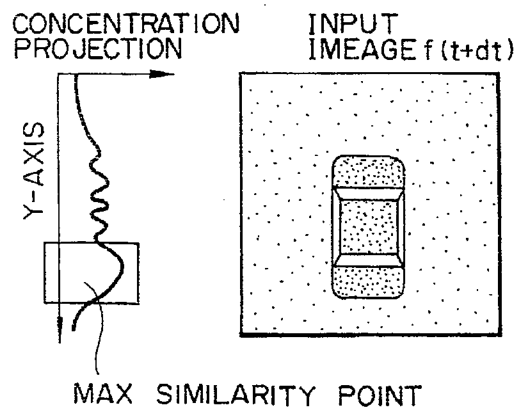


FIG. 20A

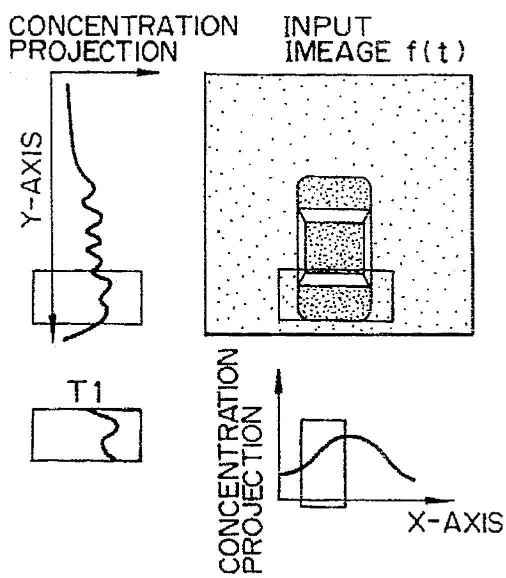


FIG. 20B

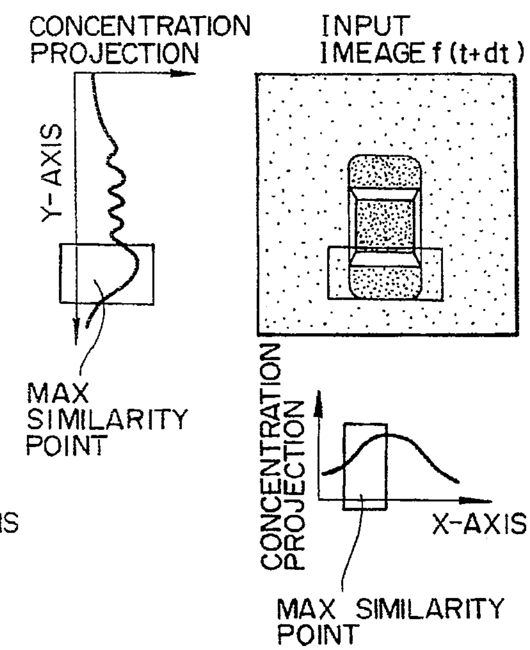


FIG. 21

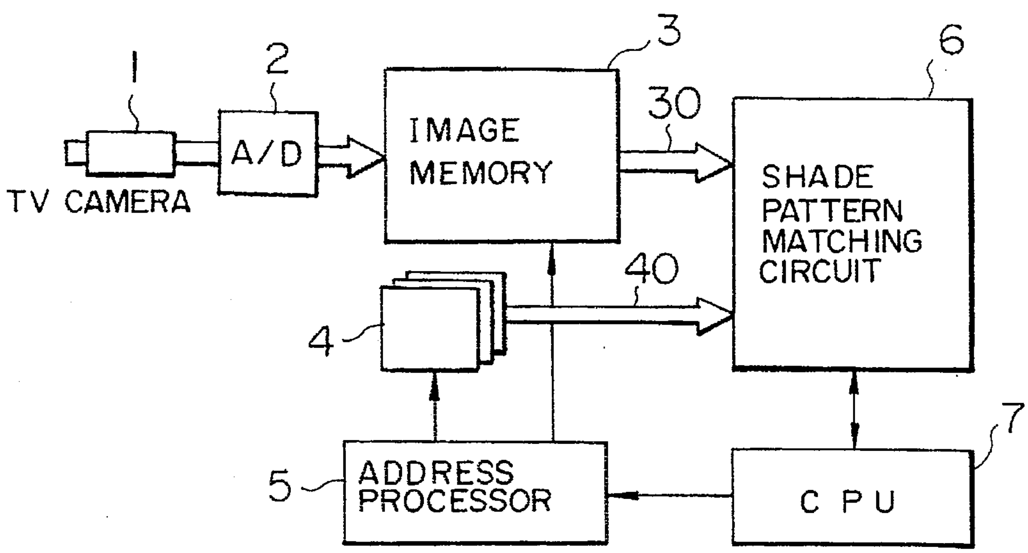


FIG.22A

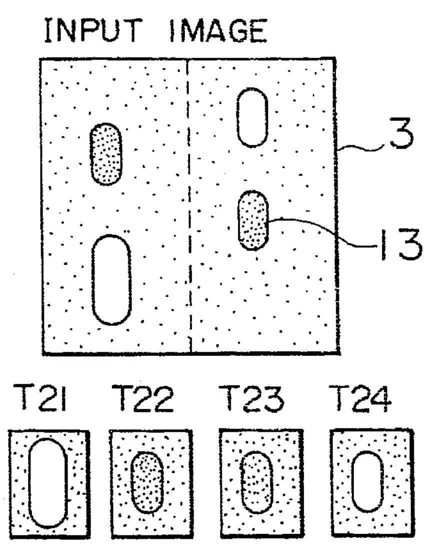


FIG.22B

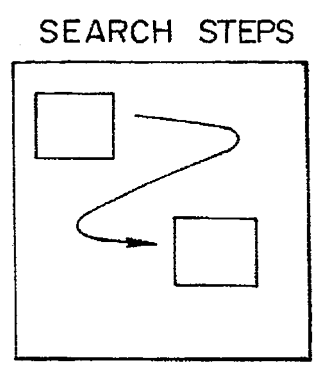
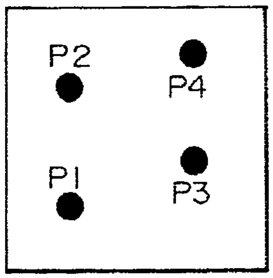
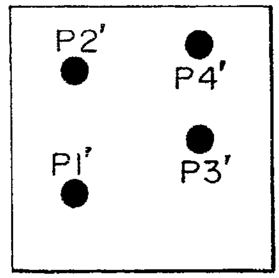


FIG. 23A



TIME t

FIG. 23B



TIME t+Δt

FIG. 24A

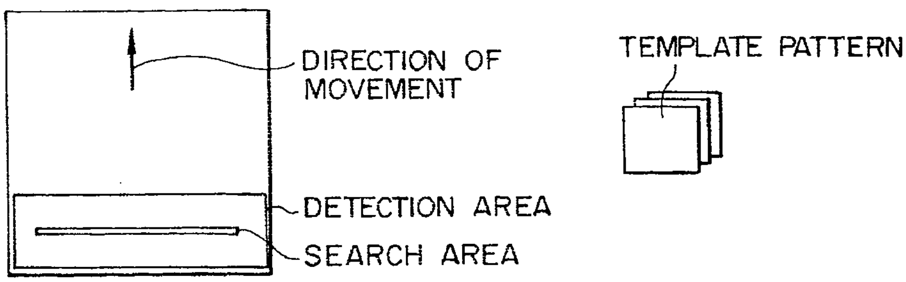
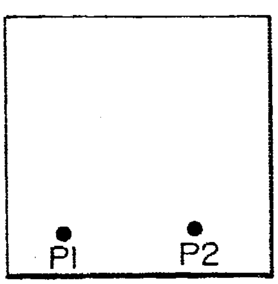
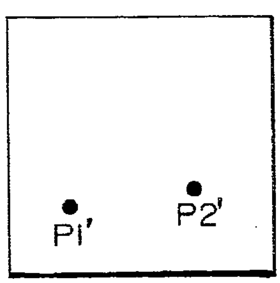


FIG. 24B



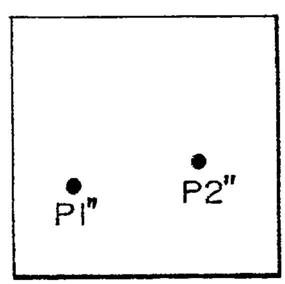
P1 (x0, y0)
P2 (x10, y10)
TIME t

FIG. 24C



P1' (x1, y1)
P2' (x11, y11)
TIME t1

FIG. 24D



P1" (x2, y2)
P2" (x12, y12)
TIME t2

FIG. 25

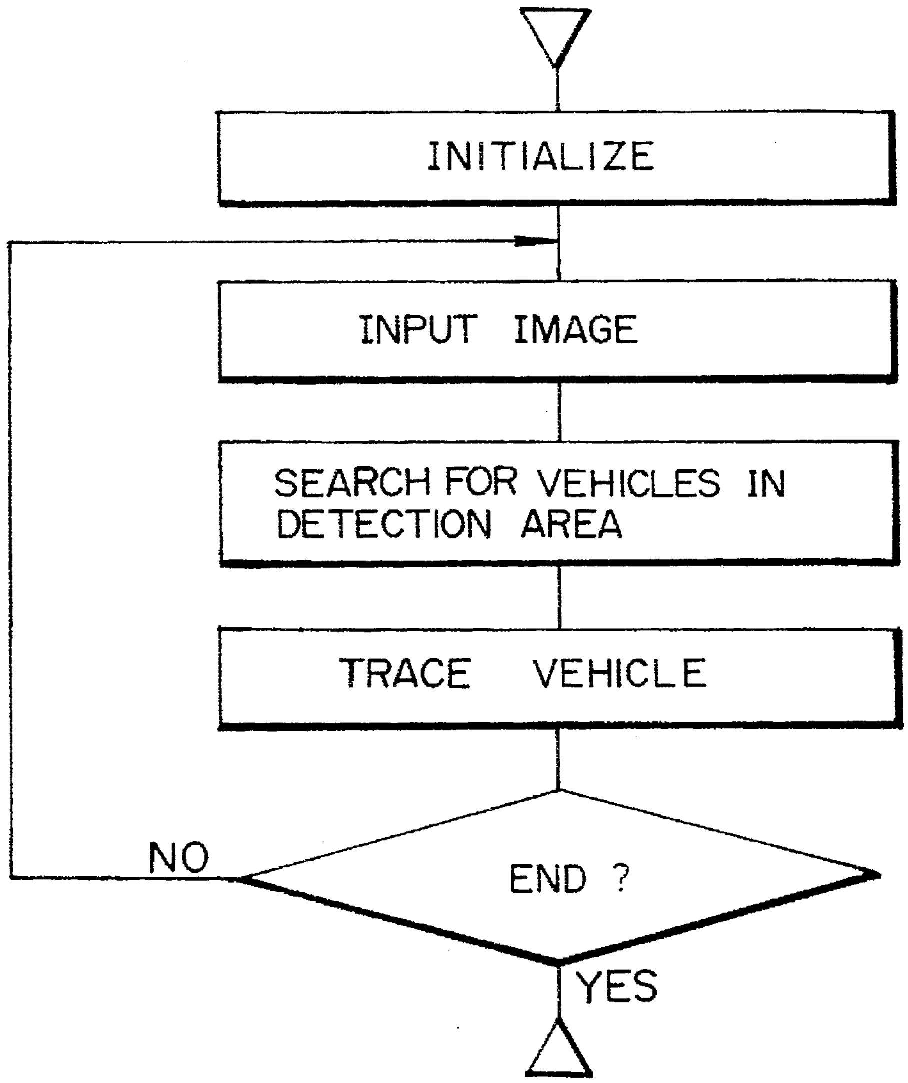

INITIALIZE
INPUT IMAGE
SEARCH FOR VEHICLES IN DETECTION AREA
TRACE VEHICLE
END ?
NO
YES

FIG. 26

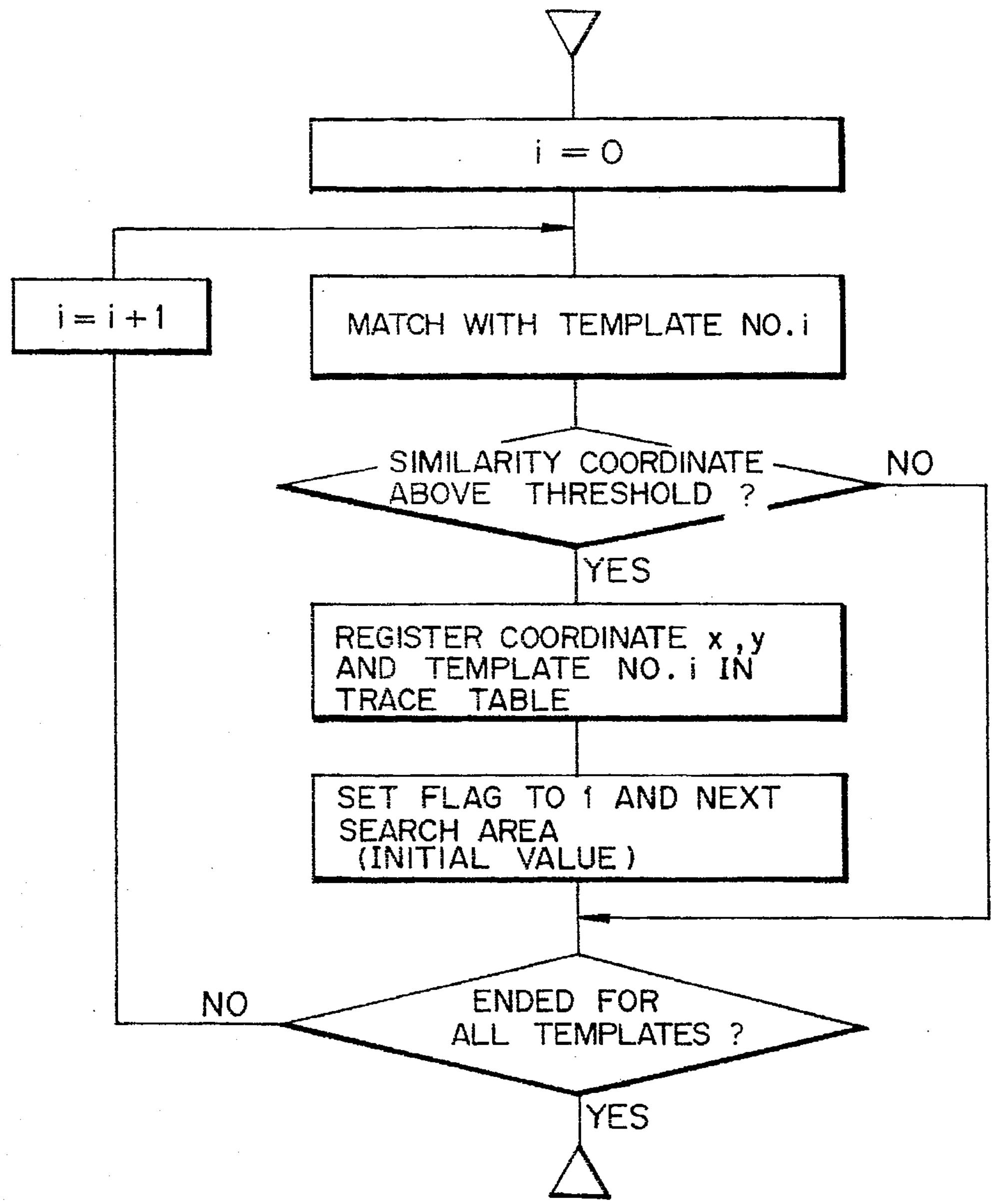

i = 0
MATCH WITH TEMPLATE NO. i
i = i + 1
SIMILARITY COORDINATE ABOVE THRESHOLD ?
NO
YES
REGISTER COORDINATE x , y AND TEMPLATE NO. i IN TRACE TABLE
SET FLAG TO 1 AND NEXT SEARCH AREA (INITIAL VALUE)
ENDED FOR ALL TEMPLATES ?
NO
YES

FIG. 27

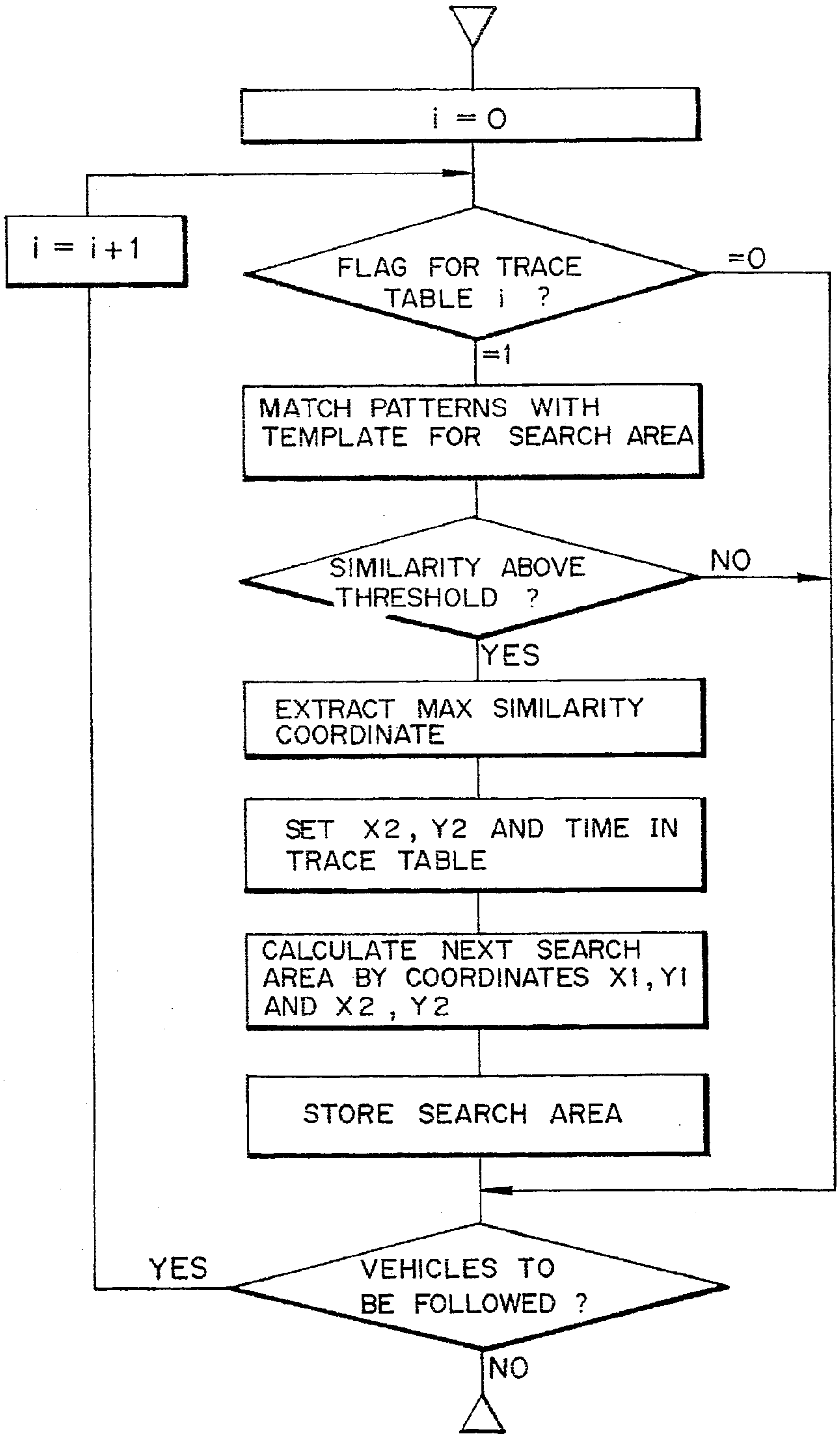

i = 0
i = i+1
FLAG FOR TRACE TABLE i ?
=0
=1
MATCH PATTERNS WITH TEMPLATE FOR SEARCH AREA
SIMILARITY ABOVE THRESHOLD ?
NO
YES
EXTRACT MAX SIMILARITY COORDINATE
SET X2, Y2 AND TIME IN TRACE TABLE
CALCULATE NEXT SEARCH AREA BY COORDINATES X1, Y1 AND X2, Y2
STORE SEARCH AREA
YES
VEHICLES TO BE FOLLOWED ?
NO

FIG. 28

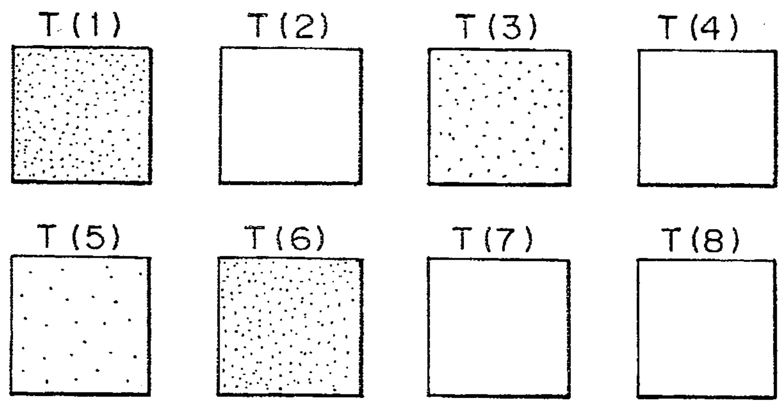


FIG. 29

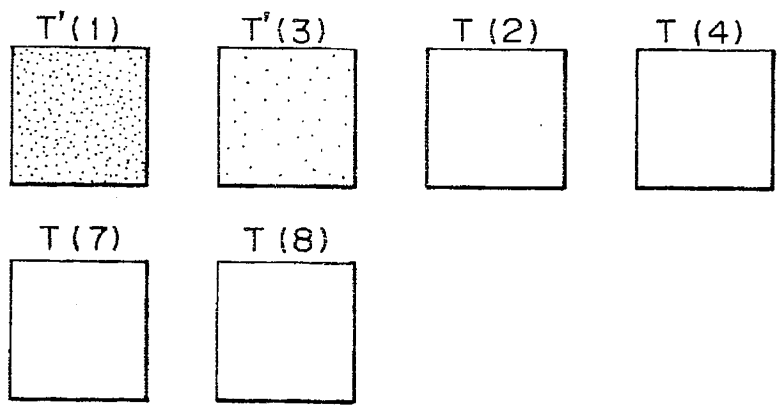


FIG. 30

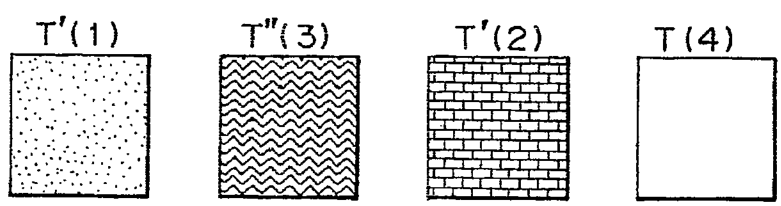


FIG. 31

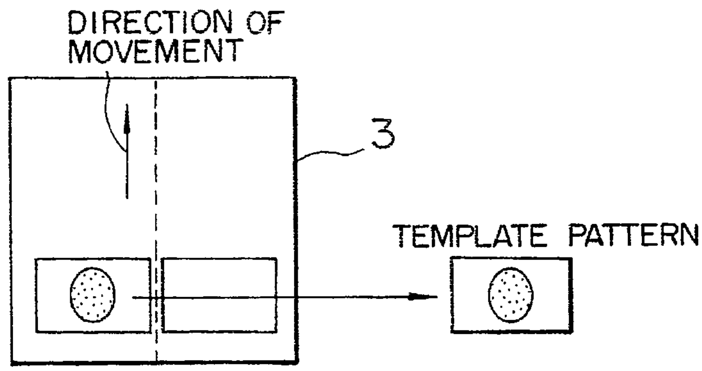


FIG. 32

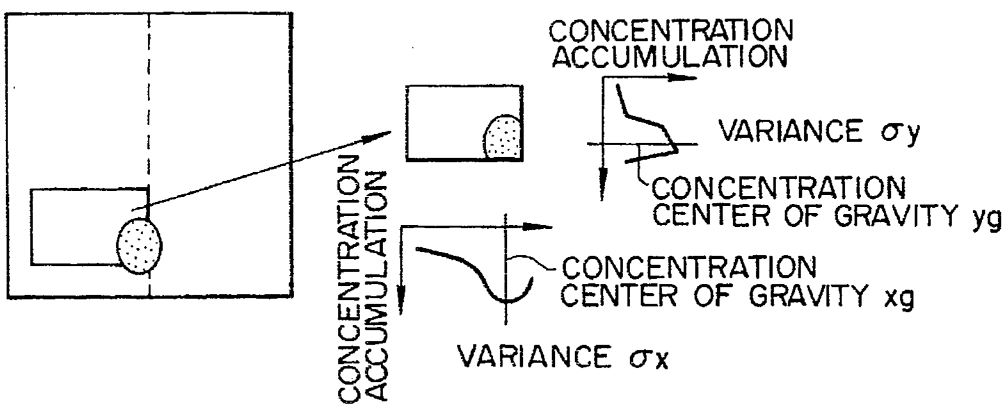


FIG. 33

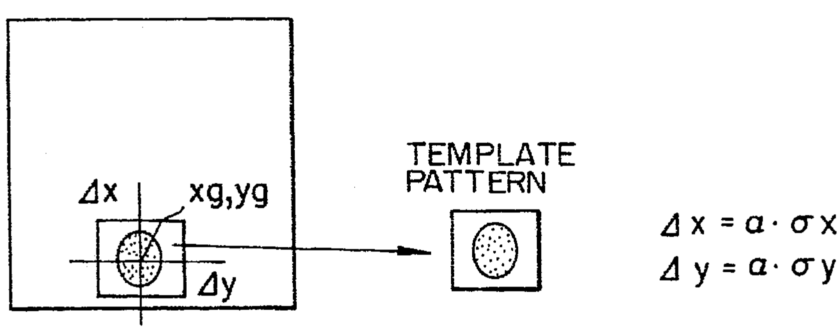


FIG. 34

FIG.35A

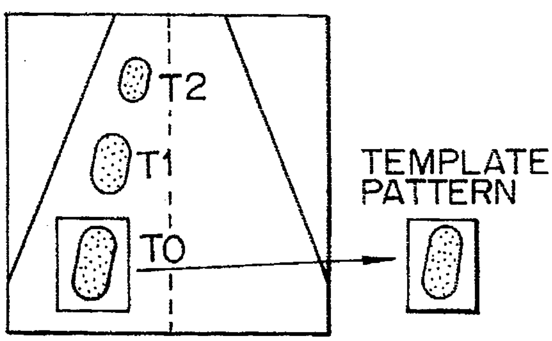


FIG.35B

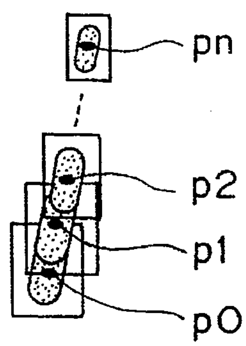


FIG. 36

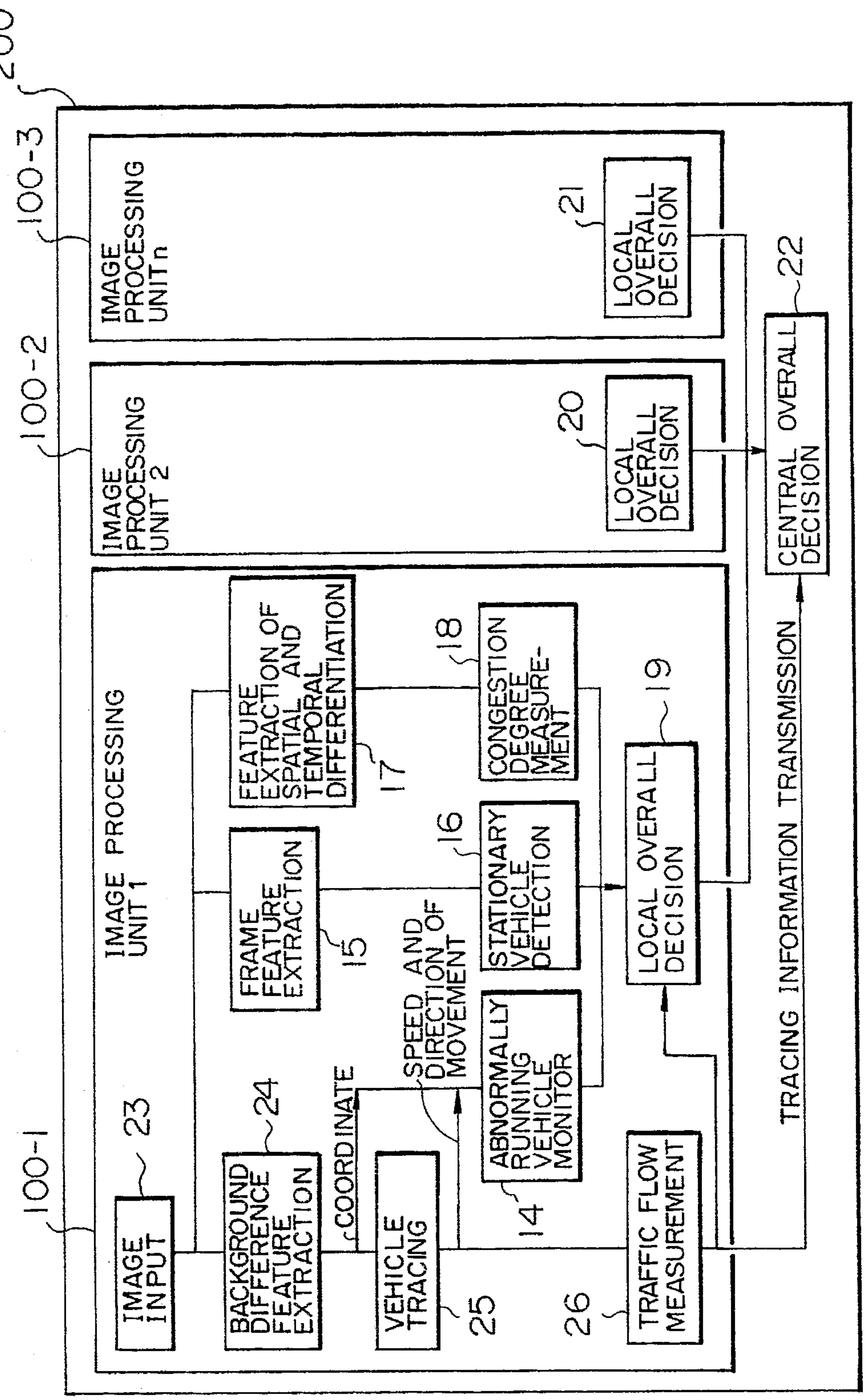

200
100-1
100-2
100-3
IMAGE PROCESSING UNIT 1
IMAGE PROCESSING UNIT 2
IMAGE PROCESSING UNIT n
IMAGE INPUT
23
BACKGROUND DIFFERENCE FEATURE EXTRACTION
24
COORDINATE
VEHICLE TRACING
25
SPEED AND DIRECTION OF MOVEMENT
ABNORMALLY RUNNING VEHICLE MONITOR
14
FRAME FEATURE EXTRACTION
15
STATIONARY VEHICLE DETECTION
16
FEATURE EXTRACTION OF SPATIAL AND TEMPORAL DIFFERENTIATION
17
CONGESTION DEGREE MEASUREMENT
18
LOCAL OVERALL DECISION
19
20
21
TRAFFIC FLOW MEASUREMENT
26
TRACING INFORMATION TRANSMISSION
CENTRAL OVERALL DECISION
22

FIG. 37

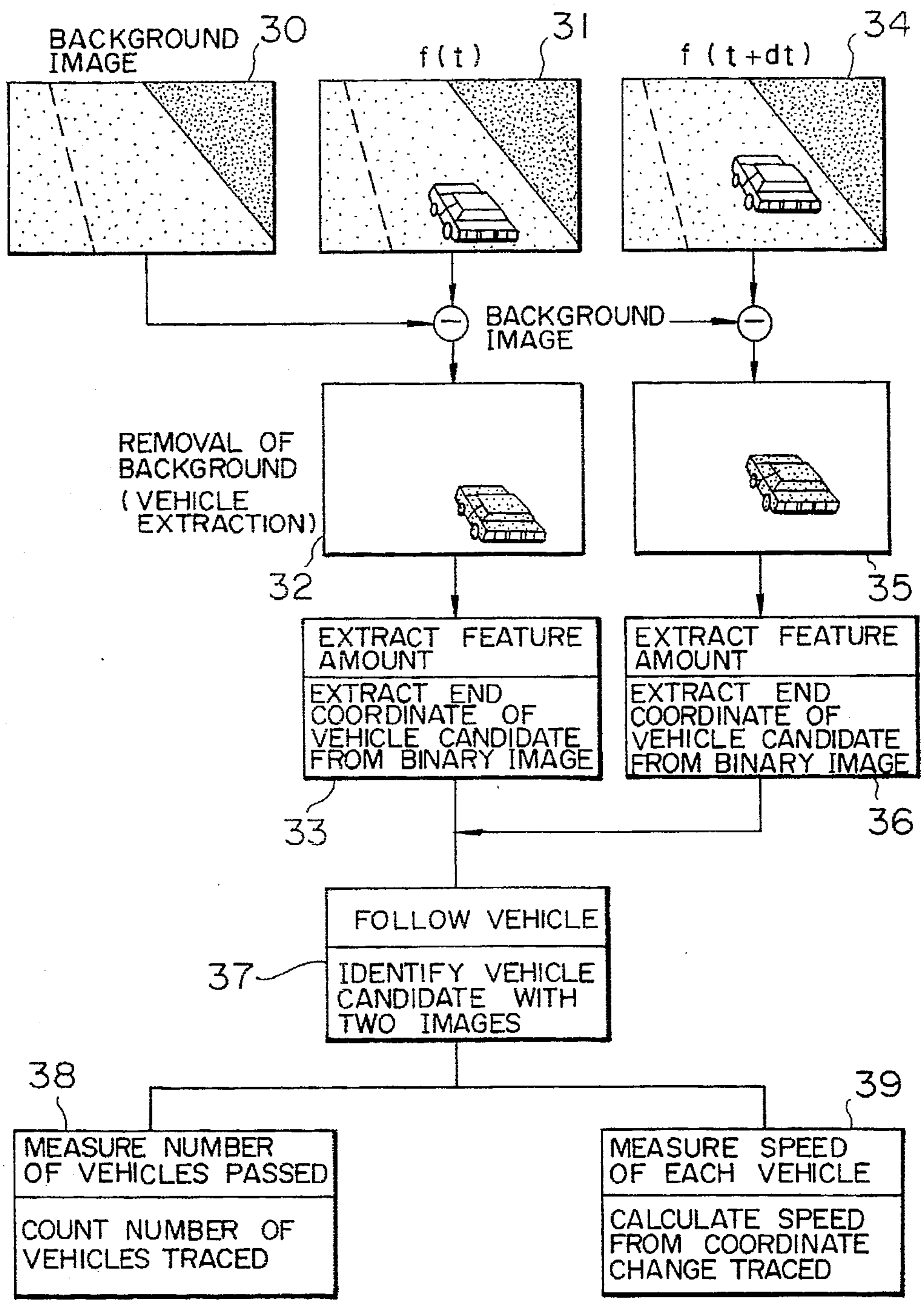
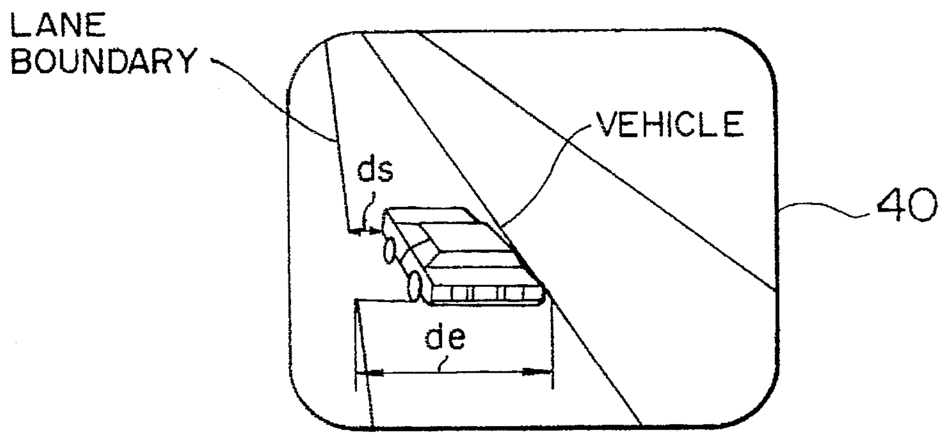

BACKGROUND IMAGE
30
f(t)
31
f(t+dt)
34
BACKGROUND IMAGE
REMOVAL OF BACKGROUND (VEHICLE EXTRACTION)
32
35
EXTRACT FEATURE AMOUNT
EXTRACT END COORDINATE OF VEHICLE CANDIDATE FROM BINARY IMAGE
33
EXTRACT FEATURE AMOUNT
EXTRACT END COORDINATE OF VEHICLE CANDIDATE FROM BINARY IMAGE
36
FOLLOW VEHICLE
37
IDENTIFY VEHICLE CANDIDATE WITH TWO IMAGES
38
MEASURE NUMBER OF VEHICLES PASSED
COUNT NUMBER OF VEHICLES TRACED
39
MEASURE SPEED OF EACH VEHICLE
CALCULATE SPEED FROM COORDINATE CHANGE TRACED

FIG. 38



ds : DISTANCE FROM LANE BOUNDARY TO LEFT COORDINATE OF VEHICLE

de : DISTANCE FROM LANE BOUNDARY TO RIGHT COORDINATE OF VEHICLE

FIG. 39A

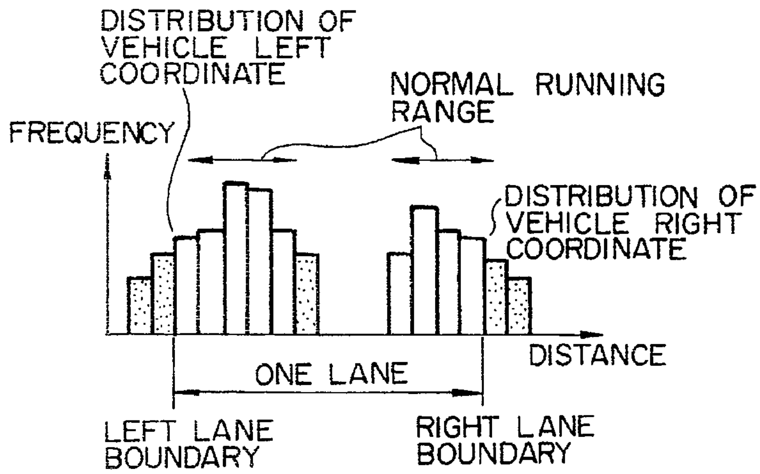


FIG. 39B

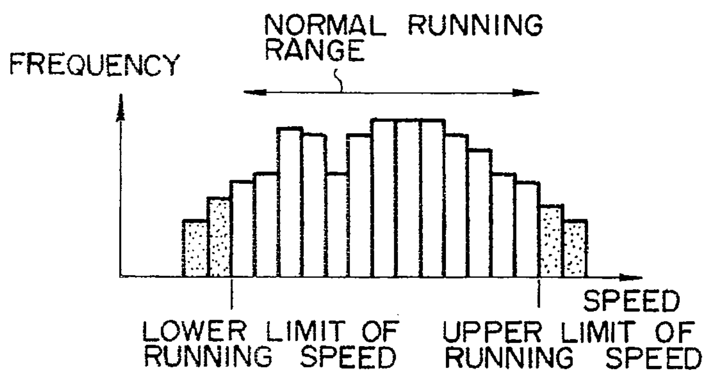


FIG. 39C

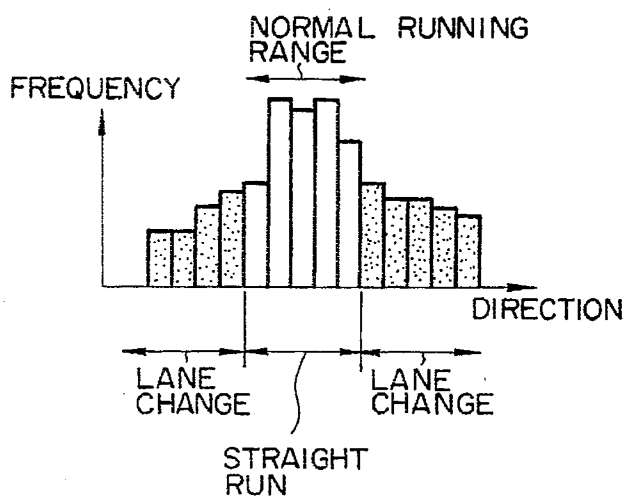


FIG. 40

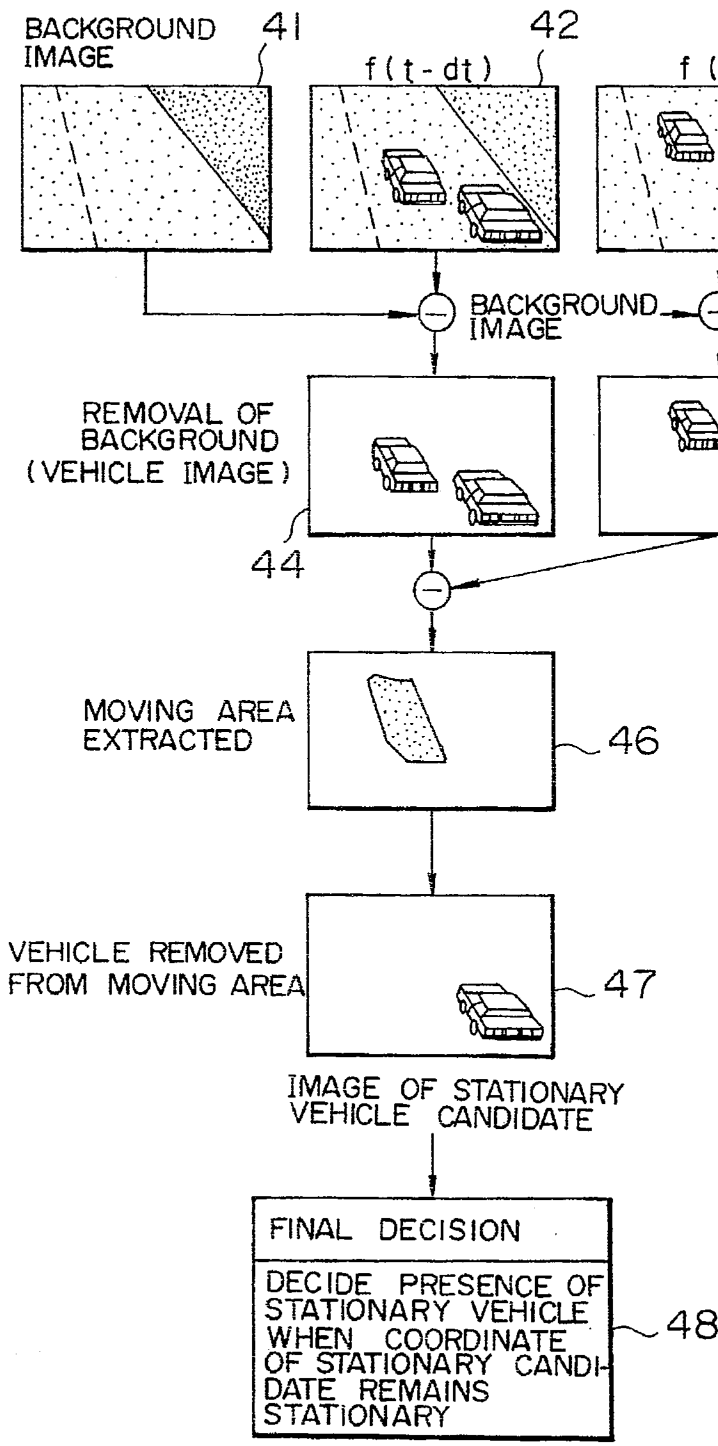

BACKGROUND IMAGE
41
42
f(t-dt)
43
f(t)
BACKGROUND IMAGE
REMOVAL OF BACKGROUND (VEHICLE IMAGE)
44
45
MOVING AREA EXTRACTED
46
VEHICLE REMOVED FROM MOVING AREA
47
IMAGE OF STATIONARY VEHICLE CANDIDATE
FINAL DECISION
DECIDE PRESENCE OF STATIONARY VEHICLE WHEN COORDINATE OF STATIONARY CANDIDATE REMAINS STATIONARY
48

FIG. 41

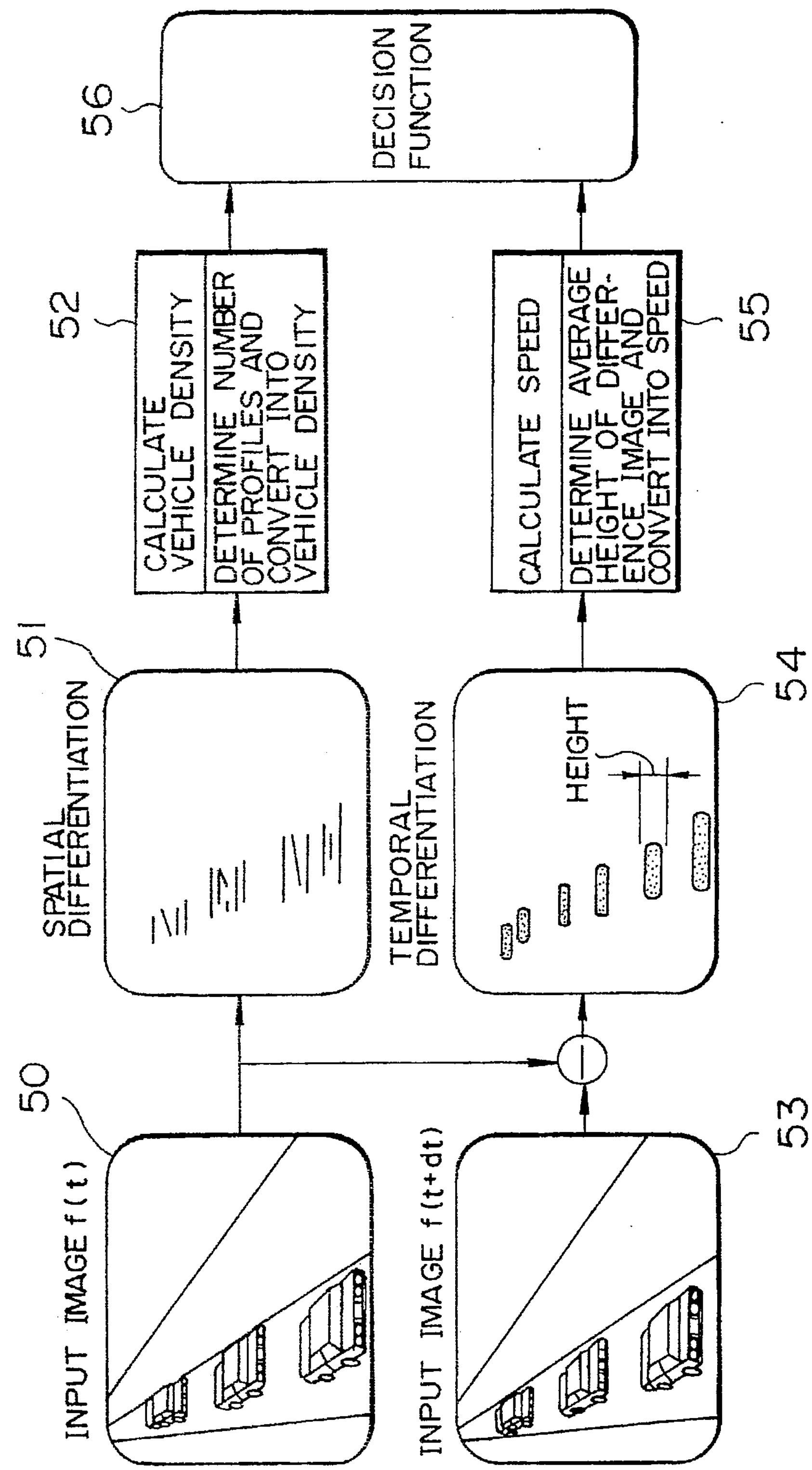

INPUT IMAGE f(t)
50
INPUT IMAGE f(t+dt)
53
SPATIAL DIFFERENTIATION
51
TEMPORAL DIFFERENTIATION
54
HEIGHT
CALCULATE VEHICLE DENSITY
DETERMINE NUMBER OF PROFILES AND CONVERT INTO VEHICLE DENSITY
52
CALCULATE SPEED
DETERMINE AVERAGE HEIGHT OF DIFFER-ENCE IMAGE AND CONVERT INTO SPEED
55
DECISION FUNCTION
56

FIG. 42

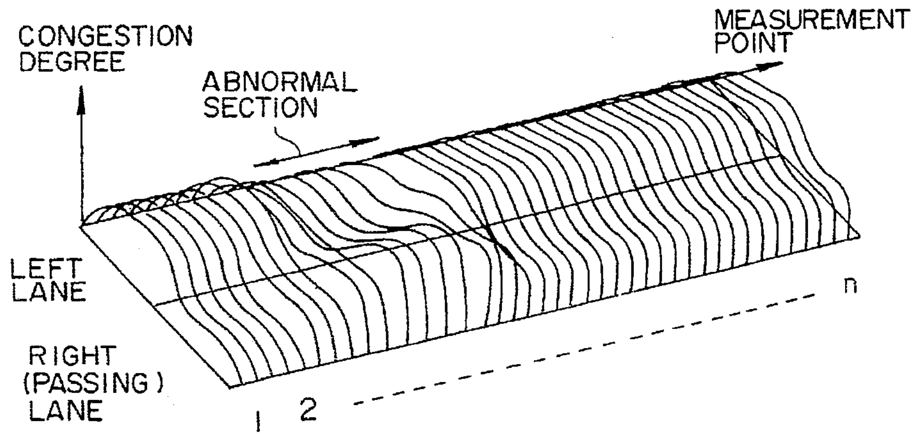

CONGESTION DEGREE
ABNORMAL SECTION
MEASUREMENT POINT
LEFT LANE
RIGHT (PASSING) LANE
1
2
n

FIG. 43

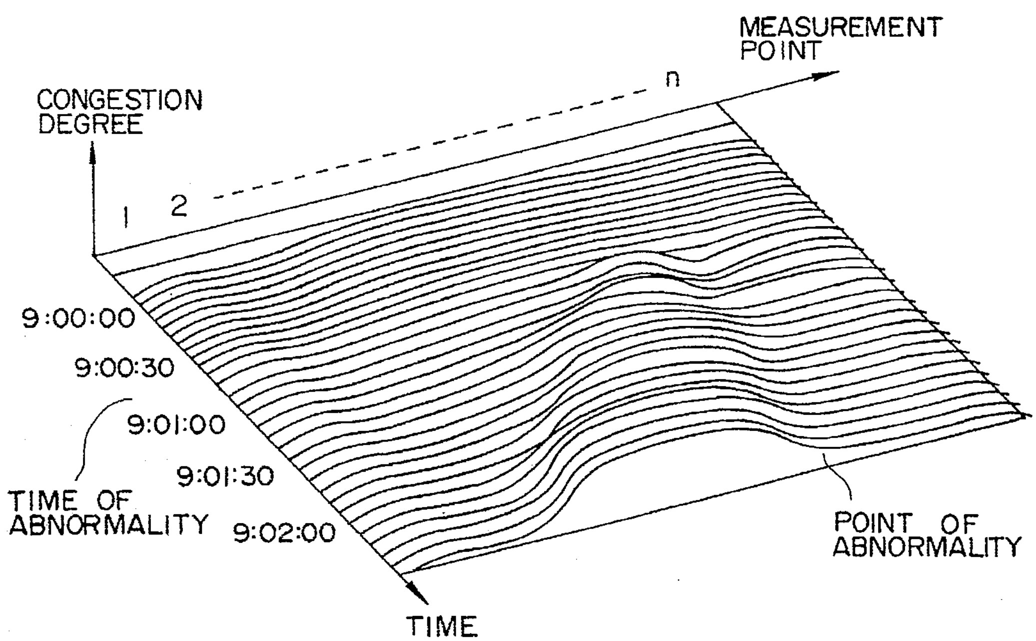

MEASUREMENT POINT
CONGESTION DEGREE
n
1
2
9:00:00
9:00:30
9:01:00
9:01:30
9:02:00
TIME OF ABNORMALITY
POINT OF ABNORMALITY
TIME

FIG. 44

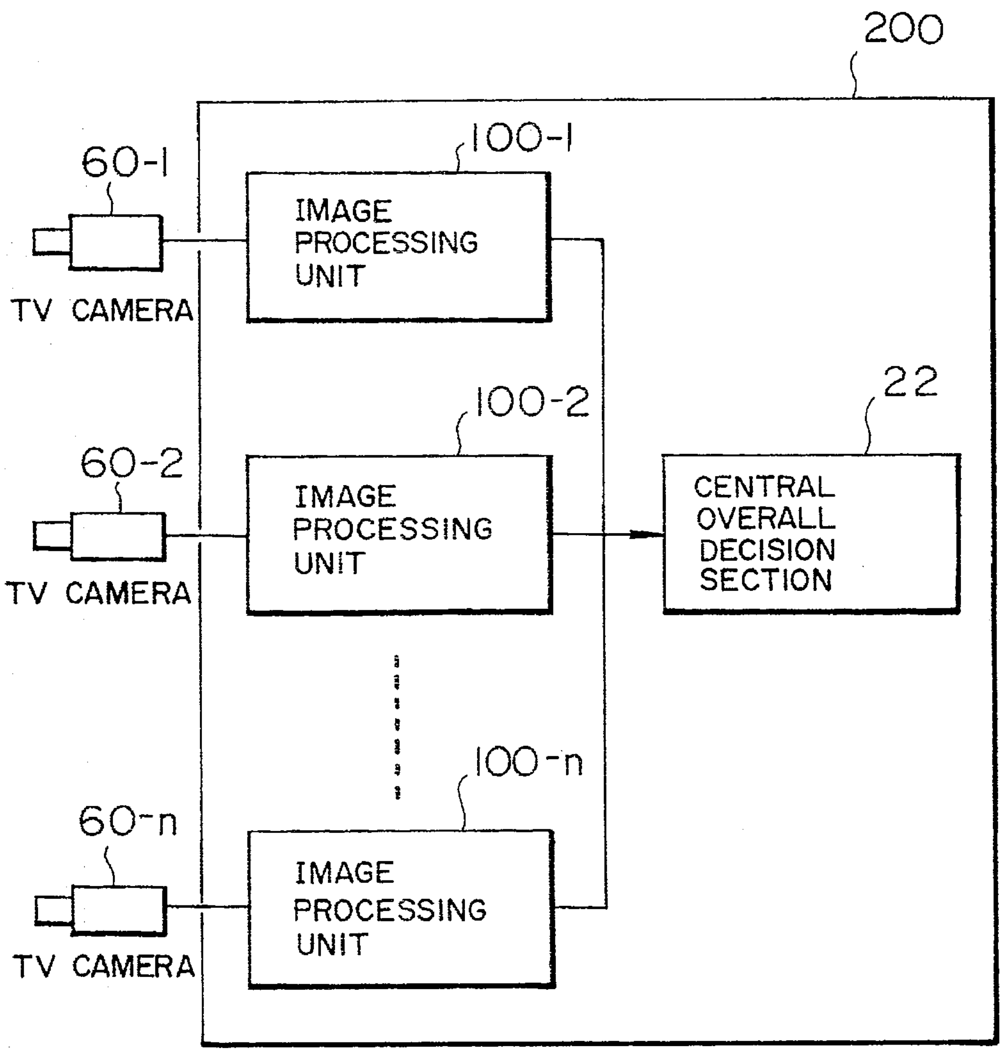

200
100-1
60-1
IMAGE PROCESSING UNIT
TV CAMERA
100-2
22
60-2
IMAGE PROCESSING UNIT
CENTRAL OVERALL DECISION SECTION
TV CAMERA
100-n
60-n
IMAGE PROCESSING UNIT
TV CAMERA

FIG. 45

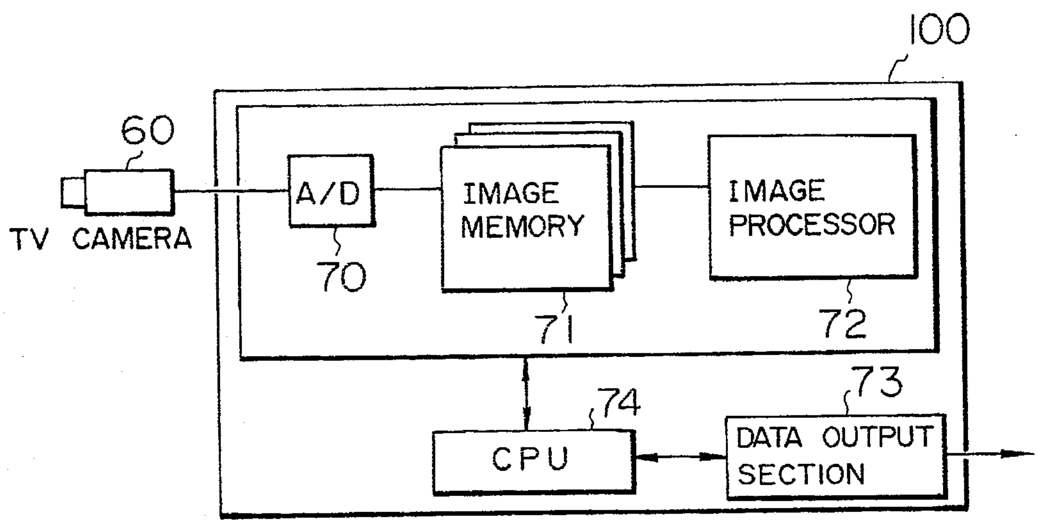
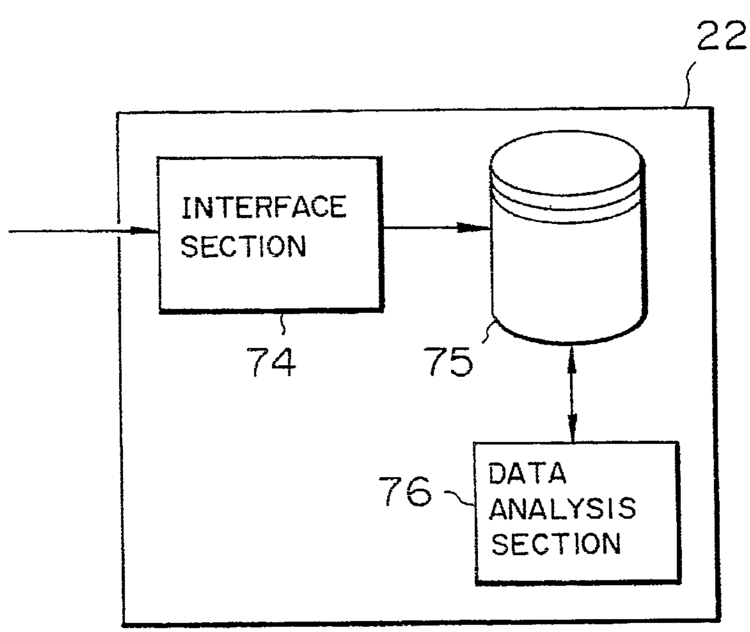

100
60
TV CAMERA
A/D
70
IMAGE MEMORY
71
IMAGE PROCESSOR
72
74
CPU
73
DATA OUTPUT SECTION

FIG. 46


22
INTERFACE SECTION
74
75
76
DATA ANALYSIS SECTION

OBJECT RECOGNITION SYSTEM AND ABNORMALITY DETECTION SYSTEM USING IMAGE PROCESSING

CROSS-REFERENCE TO RELATED APPLICATIONS

This application relates to U.S. applications Ser. No. 07/692,718 filed on Apr. 29, 1991 entitled "TRAFFIC FLOW MEASURING METHOD AND APPARATUS" issued as U.S. Pat. No. 5,283,573 on Feb. 1, 1994, Ser. No. 08/018,558, entitled "Traffic Flow Measuring Method and Apparatus" filed Feb. 17, 1993, as a continuation of the above-identified application, and Ser. No. 07/913,929 filed on Jul. 17, 1992 entitled "IMAGE RECOGNITION METHOD AND IMAGE RECOGNITION SYSTEM", assigned to the present assignee. The contents of these applications are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an object recognition system suitable for grasping motions of an object or more in particular to an object recognition system suitable for tracking a moving vehicle or the like, on the one hand, and to a system for detecting an abnormal phenomenon on a road or the like, or more in particular to a system for processing and detecting an image on a TV camera.

2. Description of the Related Art

To recognize the movement or the like motion of an object by use of image processing is considered to provide a very effective means in various applications. For example, vehicles running on the road are recognized to measure the information such as the number and speed of vehicles passed, whether they are stationary or not, etc.

Conventional systems for recognizing vehicles by processing an image on the TV camera are described in "Vehicle Recognition by DTT Method", Computer Vision, Information Processing Society of Japan, 72-5, May 1992.

To detect the traffic condition is very effective in maintaining a smooth road traffic. Systems including what is called a loop-type vehicle sensor and an ultrasonic vehicle sensor have been used for detecting the traffic condition. These systems exert ultrasonic wave or magnetism at a ground point on the road, measure the existence of a vehicle according to the change thereof, and detect the number and speed of vehicles on the basis of the time of change. These systems, however, are basically capable of determining the traffic condition only at a single ground point and therefore are disadvantageous in measuring a wide range of conditions. For this reason, a method has positively been used recently, in which an image obtained from the TV camera is processed to measure the traffic condition, as described in JP-A-2-122400. According to the conventional system disclosed in JP-A-3-204783, on the other hand, a moving object is traced by center-of-gravity calculation of a binary-coded input shade image from the TV camera. Another conventional system disclosed in JP-A-62-180488 concerns character recognition but not the recognition of a mobile object. According to the last-mentioned method, a multi-valued template is prepared and decomposed into a plurality of binary templates, so that similarity between the binary template and a binary-coded input image is determined by pattern matching thereby to achieve character recognition.

The prior art relating to pattern matching is disclosed in JP-A-63-98070, etc.

Further, early detection of an abnormal phenomenon on the road is important in maintaining a smooth road traffic.

Specifically, it is necessary to detect an accident, a stationary vehicle, a fallen object or the like at an early time and prevent the secondary damage from being caused by such an abnormal phenomenon. Detection of an abnormal phenomenon in a tunnel is especially important. Systems applicable to such a purpose are expected to be developed more and more.

According to the conventional image processing systems, however, only what is called "the traffic flow data" including the number and speed of vehicles is measured, but the configuration thereof lacks means to detect various abnormal phenomena. An example of such a conventional traffic flow measuring system is disclosed in "Architecture of Traffic Flow Measuring System Using Image Processing" in a paper for Lecture at the 37th National Convention of Information Processing Society of Japan, 6T-6, 1988.

In the "Vehicle Recognition Using DTT Method" described above, an input image is differentiated and binary-coded, a binary projection distribution along X axis (horizontal direction) of this binary image is determined, and only the coordinates of this projection distribution beyond a predetermined threshold value are stored, thus determining the trace of vehicles. This process has been conventionally employed in most cases of measuring the number and speed of vehicles by image processing, thereby posing the problem that it is difficult to set a binary-coded threshold value on the one hand and measurement is difficult when vehicles are superposed one on another on the other.

According to the conventional techniques disclosed in JP-A-2-122400, JP-A-3-204783, JP-A-62-180488 and JP-A-63-98070, the number and speed of vehicles are measured by image processing in most cases through the processes of differentiation of input image, binary-coding and feature measurement. The problem of these methods is that a binary-coded threshold value cannot be easily set and measurement is difficult for vehicles superposed. Also, the conventional technique for binary-coding and center-of-gravity calculation of an input shade image encounters the problem that the image contrast is reduced by the change in the environment or situation in which the system is installed, thereby making it sometimes impossible to discriminate a vehicle from the background. The decomposition of a multi-valued template into a plurality of binary templates for pattern matching fails to recognize a moving object accurately.

As for abnormal phenomena in a tunnel, TV cameras are not actually installed at sufficiently short intervals to monitor the entire area in the tunnel. No one can predict where an abnormal phenomenon occurs. According to the conventional traffic flow measuring functions, therefore, it is virtually impossible for the conventional traffic flow measuring functions alone to measure abnormal phenomena occurring outside of the visual field of TV cameras. Another disadvantage of the conventional systems is that all abnormal phenomena cannot be grasped with the data on traffic flow.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention, there is provided an object recognition system comprising a shade template memory circuit storing images at specified points of an object, a shade pattern matching circuit matching

patterns between the shade template and an input image, and an integral processing section determining the position of an object by searching for an input image analogous to the one of the shade template, defining the speed and direction of vehicle movement by the coordinate change of the position of the object, and identifying that templates identical in behaviour represent the same object, wherein a unique area or feature area is picked up from an image of an object, the unique image is registered as a shade template, a point of movement is determined for each template by shade pattern matching, the speed and direction of vehicle movement are determined from information on the determined points of movement, and the result of the determination is integrated to recognize the whole of moving objects.

This technique will hereinafter be referred to as "Partial Correlation Integration Method (PCIM)".

According to this method, even for an object of low contrast such as in the case of a black vehicle located in a shadow environment, for example, portions of the object high in contrast can be registered as a shade template and integrated by post-processing. As a result, a moving object can be followed or tracked in satisfactory manner in spite of a change in brightness or superposition of objects which may occur.

According to a second aspect of the present invention, there is provided an object recognition system further comprising a template updating section whereby shade templates used by being extracted from an input shaded image are sequentially updated with the movement of an object to be detected, so that the shade templates are sequentially updated and therefore moving objects can be followed even when the shape or the like thereof undergoes a change over a long period of time.

According to a third aspect of the present invention, there is provided an abnormality detection system, in which "traffic flow measurement", "detection of stationary vehicles", "detection of abnormally-running vehicles" and "measurement of congestion degree" are executed within the visual field of TV cameras, and the result of these measurements is interpolated in space and time thereby to detect an abnormal phenomenon in other than the visual field.

Further, in order to determine various abnormal phenomena accurately, the various functions mentioned above are judged integrally or synthetically.

By way of explanation, the "traffic flow measurement" is for measuring the speed and number of vehicles in the visual field of TV cameras, the "detection of abnormally-running vehicles" for monitoring the running pattern of vehicles in the visual field of TV cameras, the "detection of stationary vehicles" for detecting a vehicle stationary or out of order or a fallen object within the visual field of TV cameras, and the "measurement of congestion degree" for stepwise measurement of the degree of vehicle congestion. An abnormality judgement is made by considering these factors as a whole. The above-mentioned functions are measured at each ground point, and the resulting data are spatially interpolated to predict an abnormality outside of the visual field of TV cameras.

Accurate detection of various abnormal phenomena is thus made possible, and any abnormal phenomenon outside of the visual field of TV cameras can also be detected.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram for explaining an embodiment of the present invention.

FIGS. **2**A and **2**B are illustrations showing an example of processing of shade pattern matching.

FIGS. **3**A and **3**B are illustrations showing an example of processing of partial shade pattern matching.

FIG. **4** is a diagram showing traces of "time" and "ordinates" obtained by partial shade pattern matching.

FIG. **5** is a diagram-showing traces of "time" and "abscissa" obtained by partial shade pattern matching.

FIG. **6** is a diagram showing a model of an object image with moving objects followed by the partial correlation integration method.

FIG. **7** is a diagram showing traces of "time" and "ordinates" obtained by processing according to the partial correlation integration method.

FIG. **8** is a diagram showing a search area limitation method applied in following a moving object.

FIG. **9** is a diagram for explaining the relation between the speed of a moving object and the range of direction in which it moves.

FIGS. **10**A and **10**B are diagrams for explaining the search area for each template applied in following a moving object.

FIG. **11** is a diagram for explaining a template size determination method with a bird's eye view of a road.

FIG. **12** is a diagram for explaining the vehicle movement at an intersection.

FIG. **13** is a diagram showing an example of a shade pattern matching circuit used for updating the template.

FIGS. **14**A and **14**B are illustrations showing the processing executed when vehicles are running in parallel.

FIG. **15** is a diagram showing traces of "time" and "ordinates" plotted when vehicles are running in parallel.

FIG. **16** is a diagram for explaining a method of assuring satisfactory processing even when vehicles are running in parallel.

FIG. **17** is a diagram for explaining traces of "time" and "ordinate" plotted using a method of assuring satisfactory processing even when vehicles are running in parallel.

FIG. **18** is a diagram for explaining traces of "time" and "abscissa" plotted using a method of assuring satisfactory processing even when vehicles are running in parallel.

FIGS. **19**A and **19**B are illustrations for explaining a technique for following a vehicle by correlation calculation on the basis of a shade projection distribution.

FIGS. **20**A and **20**B are illustrations showing a method of following a vehicle along abscissa with correlation calculation on the basis of a shade projection distribution.

FIG. **21** is a diagram for explaining another embodiment of the present invention.

FIGS. **22**A and **22**B are illustrations showing an example of the processing of shade pattern matching.

FIGS. **23**A and **23**B are diagrams showing the coordinates detected by shade pattern matching.

FIGS. **24**A to **24**D are diagrams for explaining the manner in which a moving object is followed.

FIG. **25** is a diagram showing an example of main flow in following a moving object.

FIG. **26** is a diagram showing an example of the flow of vehicle search processing in a detection area with a moving vehicle followed.

FIG. **27** is a diagram showing an example of the flow of following a vehicle as a moving object.

FIG. **28** is a diagram showing an example of processing for minimizing the number of templates.

FIG. **29** is a diagram showing another example of processing for minimizing the number of templates.

FIG. **30** is a diagram showing the processing for minimizing the number of templates.

FIG. **31** is a diagram showing an example of preparation of an initial template image of a vehicle.

FIG. **32** is a diagram showing the condition of a vehicle displaced from an extracted area.

FIG. **33** is a diagram for explaining a vehicle set at the center of an extracted area.

FIG. **34** is a diagram for explaining the manner in which the size of a template image is determined in accordance with the vehicle size.

FIGS. **35A** and **35B** are illustrations showing a method of updating a template with the vehicle size changing.

FIG. **36** is a block diagram showing the configuration of an abnormality detection system according to an embodiment of the present invention.

FIG. **37** is a flowchart for explaining the outline of processing of traffic flow measurement.

FIG. **38** is a diagram for explaining the outline of processing of monitoring abnormally-running vehicles.

FIGS. **39A**, **39B** and **39C** are diagrams for explaining an example of data accumulated as obtained for monitoring abnormally-running vehicles.

FIG. **40** is a flowchart for explaining the outline of processing of detecting a stationary vehicle.

FIG. **41** is a diagram for explaining the outline of processing of congestion degree measurement.

FIG. **42** is a diagram for explaining an example of the principle of spatial interpolation between cameras.

FIG. **43** is a diagram for explaining an example of the principle of time interpolation between cameras.

FIG. **44** is a block diagram showing an example of hardware configuration of an abnormal detection system according to the present invention.

FIG. **45** is a block diagram showing a specific configuration of an image processing unit in FIG. 44.

FIG. **46** is a block diagram showing a specific configuration of a central overall decision section in FIG. 44.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of the present invention will be described with reference to the accompanying drawings. By way of explanation, a road is photographed by TV camera with the description made about a technique of recognizing vehicles running on the road. This technique is applicable not only to measurement of behaviour of not only vehicles but all other objects.

FIG. **1** diagrammatically shows a configuration of a system according to the present invention. An image from a TV camera **1** or the like is applied to an image memory **3** through an A/D converter **2** for converting an analog data into a digital data. The image memory **3** is a shade image memory of about 8 bits. A shade template memory circuit **4**, on the other hand, is for storing shade templates of a shaded image. The shade image memory **3** and the shade template memory circuit **4** are configured to scan the interior of the memory by an address processor **5**. The shade template memory circuit **4** is for storing a template area cut out of an image through a template extracting circuit **8**. The shade template memory circuit **4** also has a plurality of shade templates for storing various shade images. A shade pattern matching circuit **6** is for determining the matching between the image data **30** of the image memory **3** and the image data **40** of the shade template memory circuit **4**, and for executing the normalized correlation calculation of a normal level or less.

In normalized correlation of an input image f(x, y) against a shade template T(p, q), the similarity r(u, v) of the point of input image f(u, v) is given as

$$r(u,v)=\frac{\left[pq\sum_{i=0}^{p}\sum_{j=0}^{q}\{f(u+i,v+j)\times T(i,j)\}-\left\{\sum_{i=0}^{p}\sum_{j=0}^{q}f(u+i,v+j)\sum_{i=0}^{p}\sum_{j=0}^{q}T(i,j)\right\}\right]^2}{\left[pq\sum_{i=0}^{p}\sum_{j=0}^{q}f(u+i,v+j)^2-\left\{\sum_{i=0}^{p}\sum_{j=0}^{q}f(u+i,v+j)\right\}^2\right]}\times\frac{1}{\left[pq\sum_{i=0}^{p}\sum_{j=0}^{q}T(i,j)^2-\left\{\sum_{i=0}^{p}\sum_{j=0}^{q}T(i,j)\right\}^2\right]} \quad (1)$$

where p, q are x, y sizes of a gray scale or shade template, respectively. Any method of determining a correlation may be used to the extent that an effect similar to the above-mentioned method is obtained.

The operation of the image memory **3**, the scanning of the shade template memory circuit **4** and the operation of the shade pattern matching circuit **6** are all controlled by a CPU (not shown). More specifically, the address processor **5** and the shade pattern matching circuit **6** are activated by the CPU, the image address given in Equation (1) is generated at the address processor **5**, a data is read from the image memory **3** and the shade template memory circuit **4**, a data is determined as required for similarity calculation at the shade pattern matching circuit **6**, and the similarity r(u, v) is calculated at the CPU. A coordinate with a large similarity, once determined, is stored in a trace management table **9** for managing the "time", "abscissa" and "time", "ordinate". Then, the isolation/integration processing is effected by an isolation/integration processing circuit **10** against the trace management table. To explain the shade pattern matching circuit **6** briefly, the data relating to a shade template is capable of being calculated in advance, and therefore the data relating to an input image is calculated and transmitted to the CPU at the time of calculating a similarity. The data relating to an input image is determined by the calculation according to Equation (4) from Equation (2) through the shade pattern matching circuit **6** in the above-mentioned case. The same operation may be shared by the shade template memory circuit **4** and the image memory **3**.

$$\sum_{i=0}^{p}\sum_{j=0}^{q}f(u+i,\ v+i) \quad (2)$$

-continued

$$\sum_{i=0}^{p}\sum_{j=0}^{q} f(u+i, v+j)^2 \quad (3)$$

$$\sum_{i=0}^{p}\sum_{j=0}^{q} \{f(u+i, v+i)\times T(i, j)\} \quad (4)$$

An example of shade pattern matching of an input image is shown in FIGS. 2A and 2B. In the case where a vehicle 20 is displayed on an input image f(t) at a time point t, a shade template T1 is cut out of the input image f(t), raster scanning is effected at the same time as pattern matching of an input image f(t+dt) at time point t+dt, and a coordinate is sought with an increased similarity r(u, v). Then, the maximum point of similarity is determined as shown in FIG. 2B. As a result, the instantaneous speed and direction of vehicle movement can be determined from the maximum similarity point of time point t+dt and the vehicle existence coordinate (central coordinate of template) at a time point t.

Incidentally, the horizontal axis of an image memory is referred to as X axis, and the vertical axis thereof as Y axis.

The advantage of the above-mentioned normalized correlation processing is that to the extent that a registered shade template and an image pattern are similar to each other, a similarity to some degree is obtainable even when the brightness undergoes a change or an object is hidden to some degree by something (as when vehicles are superposed on two-dimensional display or when only a portion of a vehicle is visible due to a shadow of a building or the like). More specifically, even though similar to the road surface brightness, an object can be recognized as a vehicle as long as it has a vehicular shape. According to the conventional systems using binary-coding at a certain threshold value, recognition of a vehicle of low contrast is very difficult. The technique according to the present embodiment, on the other hand, facilitates extraction of a vehicle.

Vehicles to be recognized are of various sizes, types and colors. The processing by pattern matching is accompanied by the problem of size change. Pattern matching techniques disclosed in U.S. application Ser. No. 07/789,682 filed Nov. 8, 1991 are applicable to the present invention. The contents of that application is incorporated by reference herein. As far as the pattern matching of whole vehicles is executed, the recognition of vehicle size is required in advance, thereby making it difficult to apply the system to vehicles passing at random. When a human being observes the movement of an object of considerable size, therefore, the whole of the particular object is not always followed, but the movement of a specified point thereof is followed, so that points where the movements are identical in speed and direction are finally integrated to recognize a large object. In other words, a plurality of partial templates smaller than a vehicle are prepared, and a shade pattern matching is effected for each template. The templates, for which shade patterns are matched and the resulting speeds and directions, are judged to be similar to each other and are integrated to represent the same vehicle independently of the size. In the case where no moving object exists in a registered template (in the case of an image of the road surface alone), the maximum point of similarity cannot be defined or displaced from the central coordinate of a registered template.

As will be described in detail with reference to FIG. 3, partial areas smaller than the vehicle size are set in an input image. In FIGS. 3A and 3B, templates T1 and T2 are set. These partial areas are registered as templates respectively, and matched with sequentially applied images to determine the maximum point of matching for each template. If this condition is expressed as "time" along abscissa and as "ordinate" along vertical axis as shown in FIG. 4, a trace can be determined for each template, where the unit along time axis corresponds to a sampling interval of image input. When an image is introduced for every three frames, for example, the unit is 3×1/30=100 ms. This management is effected at a trace management table 9. In view of the delicate difference in matching point with each template, the moving speed (displacement of ordinate) undergoes a change. Nevertheless, substantially similar behaviours are obtained due to the fact that the partial templates are for the same vehicle. As a result, an integration processing of these templates makes it possible to execute the recognition of a whole vehicle. An integration processing is executed at an iteration processing circuit 10. FIG. 5 is a diagram showing traces plotted as "time" along abscissa and "X coordinate" along ordinate. The discrimination of straight run and lane change is made possible by recognizing the format of the traces. FIG. 6 shows a detailed case involving two passing vehicles, in which images inputted at intervals of a certain unit time over a period from t1 to t16 are processed. Templates carry shade images of three partial areas at the lower part of the screen entered by the vehicle.

The processing steps will be briefly explained below.

(1) Three partial templates T1(t1) to T3(t1) for the front part of a vehicle are registered in the image of time point t1, where t designates time, and T a template.

(2) The shade pattern matching is effected for the image of time point t2 by use of the registered templates T1(t1) to T3(t1). As a consequence, moving traces are determined for the partial templates T1(t1) to T3(t1).

(3) Three partial templates T1(t2) to T3(t2) are registered also for the image of time point t2.

(4) In similar fashion, the shade pattern matching is effected for the image of time point t3 using the templates T1(t1) to T3(t1) and T1(t2) to T3(t2). As a result, moving traces are obtained for the partial templates T1(t1) to T3(t1) and T1(t2) to T3(t2).

(5) The above-mentioned steps of processing are sequentially repeated. In other words, the registration of partial templates at a given time point and the shade pattern matching between the partial templates registered at the preceding time points and the present image are sequentially repeated in parallel. The traces for respective partial templates are thus obtained as shown in FIG. 7. Traces for the same vehicle are located close to each other in distinction from other vehicles. The interval between two groups of close traces represents the distance between two vehicles running in the same direction, and the width of each trace group the vehicle length. The inclination of the traces, on the other hand, represents the vehicle speed.

(6) The partial templates are separated and integrated. In the case of FIG. 7, for example, the partial templates T1(t1) to T3(t1) are processed on the assumption that they represent the same object.

It will be seen that the vehicle behaviour recognition is easily executed by using this technique.

A specific example of each process will be explained below.

1. Method of separation and integration processings

The separation and integration processings after determining the moving point of each template may be executed by the technique as described below.

1.1 Integration processing

(1) The trace of each template is approximated by curve according to the least square method or the like, and those partial templates having small mutual distances are integrated.

(2) The knowledge about an object image (relating to the concentration distribution, shape, etc.) is prepared, and determination is made as to which part of the object is represented by the shape of a given template. In this way, all the templates are integrated. In the case of a vehicle, for example, assume that a template **1** represents "the left image of the tail lamp", a template **2** "the right image of the tail lamp", and a template **3** "the central image of the rear window". This knowledge permits the determination that the template **2** is positioned to the right of the template **1**, and the template **3** is arranged above them. In other words, the templates **1** to **3** are determined to represent the same object.

The size of a template is such that initial partial templates may be processed always as such (in the form of a hypothetical large template) and, after integration, as a template covering a rectangular area containing all the integrated partial templates.

1.2 Separation processing

(1) In the case where the feature amount (for example, average concentration) of some of the integrated templates suddenly increases, they are separated from the integrated pattern.

(2) The templates thus integrated are assumed to be coupled under a certain resistance. In the case where the behaviour of a given template is different from that of another template connected thereto, therefore, they are left integrated if the behaviour is not to such a degree as to cut off the resistance. If the difference is so great as to cut off the resistance, on the other hand, the affected template is separated. The resistance may be defined as a weight representing the strength of coupling or a function representing the degree of coupling.

2. Method of limiting search range

In recognizing the behaviour of a vehicle running along the road, full scanning of the correlation calculation of registered templates is not always necessary. More specifically, in view of the fact that the range of movement of a vehicle is limited to some extent, the next range of search can be specified by the past behaviour of the vehicle. The processing time of the similarity calculation is proportional to the number of picture elements (the sizes of templates and search range), and therefore, the search range should be reduced as far as possible. An example is shown in FIG. **8**. In the case where a vehicle moves from the coordinate (x**0**, y**0**) to (x**1**, y**1**), for instance, it is possible to specify the next search area by using the moving speed V and the direction of movement θ. A predicted position is included in a fan-shaped range shown in FIG. **8** as determined from the minimum speed Vmin, the maximum speed Vmax and the amount of change in the direction of movement 2ϕ against the preceding moving speed V. To simplify the processing, the rectangular area surrounding the fan-shaped area is used as the next search range. Such a search range is determined according to Equations (5) to (8) below.

$$xs=x1+Vmin\cdot\cos(\theta+\phi) \quad (5)$$

$$ys=y1+Vmax\cdot\sin(\theta+\phi) \quad (6)$$

$$xe=x1+Vmax\cdot\cos(\theta-\phi) \quad (7)$$

$$ye=y1+Vmin\cdot\sin(\theta-\phi) \quad (8)$$

where (xs, ys) represents the starting coordinate and (xe, ye) the final coordinate of an area. The range ϕ of the vehicle direction may be changed as a function of the speed V as shown in FIG. **9**. Assume that the object of recognition is other than a vehicle which is simple in behaviour pattern, or, that a human being, an animal or the like object is to be recognized and followed, for example, a simple search range as determined above is sometimes insufficient. In view of this, the past behaviour pattern is learned by a neural network in order to specify the next mobile range from the traces of past movement. If this behaviour pattern is used for prediction of the future behaviour, the resulting search range which will be more detailed is expected to reduce the processing time.

As a result, in following the vehicle coordinates **P1** to **P4** determined at a time point t as shown in FIG. **10**A, a search area can be determined as shown in FIG. **10B**, thus remarkably reducing the processing time.

3. Method of updating templates

In spite of the fact that the foregoing description concerns the case in which a road is viewed from right above, it is almost impossible actually to photograph a road from overhead. A bird's-eye view of a road is the result. In such a case, a vehicle appears smaller with the ascendance in the screen as shown in FIG. **11**. In the method of following a vehicle according to the above-mentioned correlation calculation method, therefore, a vehicle located at a far point cannot be detected and therefore cannot be followed, although detection is possible of vehicles appearing to be of the same size as the registered shade templates. This problem never fails to arise in applications involving a wide monitor range such as in monitoring human intruders or watching railroad crossings.

In view of this, a shade template is updated while following the movement of vehicles as shown in FIG. **11**. More specifically, in the case where templates with the ordinate centered at Y**1** is registered from the image of time point t**1**, assume that a similarity point is detected at the ordinate Y**2** by shade pattern matching of the image of time point t**2**. The template size in registration is reduced in accordance with the ratio determined by the coordinate Y**2**, and the shade image at time point t**2** in the vicinity of the similarity point is registered again as a template. The shade template newly registered is used for matching in the next search area. Sequential executions of this process permits the versatile operation of following vehicles against changes in vehicle size. This method has been developed on the basis of the fact that the size and direction of movement of a vehicle does not substantially change instantaneously but slowly.

A template may be prepared, instead of by the above-mentioned method using a latest input image, alternatively according to the average ((f+g)/2) of the preceding template image (g) and an image newly detected in the vicinity of a vehicle position (f) or a linear coupling calculation ($\alpha f+\beta g$, $\alpha+\beta=1$).

Assume that the number of vehicles turning to the right at an intersection is measured by using the above-mentioned technique as shown in FIG. **12**. In view of the fact that the vehicles turning to the right change the direction thereof gradually, the following of a vehicle ceases midway with a single shade template. The following of vehicles, however, is facilitated by updating the shade template at the same time. Also, the movement of a human being constantly changing in shape is capable of being followed by updating a template as described above.

When a shade template is updated, however, the data relating to the shade template in the calculation of Equation (1) mentioned above cannot be determined in advance. This value is thus required to be determined with rapidity. In view of this, a circuit may be added as shown in FIG. **13** for acquiring the data on the shade template T (i, j), so that with the registration of a shade template, the calculations of Equations (9) and (10) are executed to always permit high-speed processing.

$$\sum_{i=0}^{p}\sum_{j=0}^{q} T(i,j) \tag{9}$$

$$\sum_{i=0}^{p}\sum_{j=0}^{q} T(i,j)^2 \tag{10}$$

where p, q are constantly variable with the size of the shade template.

A template is extracted from an input image by a template extracting circuit **11**. The next template is prepared at a template update circuit **12** by averaging or linear coupling of the template thus extracted and the preceding template. The resulting template is registered and used for the next operation of following vehicles. A device for continuous following operation is thus configured.

4. Size of template

Any case of vehicles running in parallel is not described above. Actually, however, a road often has two or three lanes, and therefore, it is necessary also to be able to process the recognition of vehicles running in parallel. A case of recognition of the behaviour of vehicles running in parallel is shown in FIGS. **14**A and **14**B. Templates **T1** to **T4** are registered with respect to an input image as shown in FIG. **14**A. When these templates are used to follow the vehicle behaviour by shade pattern matching against an input image of time point t+dt, a matching point is detected for each template. If a moving trace is plotted as "time" along abscissa and "ordinate" along vertical axis, the diagram of FIG. **15** is obtained. It will be noted that in the case where the speed and direction of movement of two vehicles are substantially identical to each other, mere analysis of the traces shown in FIG. **15** cannot discriminate small and large vehicles.

This is due to the fact that the area on a road separating the two vehicles fails to be recognized. More specifically, a template exclusively covering the road cannot be registered, if each template is excessively large in size. It is, therefore, important to set the template width to not more than the vehicle intervals (along X direction). The operation with a reduced template size is shown in FIG. **16**. One or more templates (corresponding to **T5** in the case under consideration) of a size smaller than the interval between vehicles are always provided and are followed with the shade pattern matching described above. The time-ordinate and time-abscissa relationships in this state are shown in FIG. **18**. In the time-ordinate graph, which templates are associated with the same vehicle is unknown when two vehicles are running at substantially the same speed. From the observation of the time-abscissa graph, however, an area lacking a vehicle is detected, and therefore the templates **T1** to **T4** and **T6** to **T10** are known to belong to the same vehicle.

As explained above, it is important to set the template width (along X direction) to not more than the interval between vehicles in order to enable a separating point to be recognized between vehicles. At the same time, the template length (width along Y direction) may be of any size if in a range processable by correlation calculation (such a size as to permit grasping the features of the vehicle).

5. Method of template registration

A method of registering a template will be explained. A method of extracting a template followed includes using an image of a predetermined area (the simplest method being by using templates arranged on the vehicle-incoming side as shown in FIG. **16**) always as a template. According to this method, however, a vehicle cannot be followed if it reappears after being hidden behind a large vehicle or the like. In view of this, a shade image of input associated with a unique point of the whole image, such as the one with a large differentiation value (spatial frequency feature) or the one with a large difference between images obtained by differentiations taken at predetermined time intervals is set as a template, and each template thus set is followed by the correlation calculation. These templates may be combined with images on the vehicle-incoming side.

As another alternative, a learning processing is effected in such a manner as to extract an object directly from an image by use of a neural network, and a candidate image of a moving object is directly extracted by use of the result of learning, so that a shade image of an input corresponding to the particular area is extracted as a template.

By sequentially executing this processing, even if a vehicle appears in the midst of processing, the following of vehicles becomes possible at and after the time of appearance.

6. Method of correlation calculation

Although the above-mentioned "partial correlation integration method" is for executing the two-dimensional correlation calculation, the "method of correlation integration by concentration projection" involving a simplified processing has a similar effect. As an outline is shown in FIGS. **19**A and **19**B, the correlation calculation is effected on the basis of a one-dimensional concentration distribution for determining a concentration projection (concentration accumulation) along ordinate for each lane. If a partial pattern within a predetermined width of this projection distribution is followed as a template, the amount of movement along ordinate is determined. The change in abscissa, however, cannot be detected. If the detection along abscissa is to be executed, the projection (concentration accumulation) along abscissa of the concentration in the vicinity of a matching point along ordinate is determined when the particular matching point is obtained as shown in FIGS. **20**A and **20**B, and the correlation with a template in registration is defined. In this way, the change along ordinate is determined. The general procedure for the above-mentioned method is the same as the "method of partial correlation integration". Templates may be registered by a method placing sole emphasis on the change points of the projection distribution. The advantage of this method lies in that the processing time is reduced considerably as compared with the "partial correlation integration method" described above due to the fact that the template is one-dimensional.

Although the above-mentioned methods refer only to the correlation calculation of a shade image, the binary template matching or hierarchical pattern matching (both shade and binary) which have so far been employed may be executed. In such a case, too, it is important to utilize the size, separation/integration of templates or updating of template patterns.

The "method of partial correlation integration" and "method of partial correlation integration by concentration projection" according to the present invention can be used for wider applications. Apart from the human being or vehicles as an object, these methods are applicable also to the operation of following other types of moving objects. Some applications include:

(1) Detection of stationary vehicles: By following vehicle traces, the position where a vehicle has stopped is determined. The illegal parking, etc. is thus detectable.

(2) Management of parking lot: A parking lot is monitored from a high point to recognize an unoccupied area by following vehicle traces.

(3) Monitoring crossings: Whether any vehicle stays within the crossing range is recognized. The vehicle behaviour is a simple movement along lateral direction

(or along vertical direction depending on the camera position), and therefore vehicles can be followed in simple fashion.

(4) Monitoring intruders (security): Whether any suspicious person has intruded during the night time, for instance, is recognized. Since a human being is an object of recognition, a partial template smaller than the width of the human being should be used. The detection of an intruder into the railroad track from the station platform can also be processed.

According to the present embodiment, the behaviour of an object is accurately detectable by the partial correlation integration method even in the case of low contrast or superposed objects. This compares with the conventional methods in which an input image is binary-coded or a threshold value is set for a binary projection distribution, with the result that tuning is difficult with the processing performance subject to a considerable variation depending on such conditions as environments including brightness and shadow.

The present embodiment, which lacks binarized threshold values, eliminates the tuning, and is applicable to environmental changes in versatile fashion. Also, moving objects can be followed by shade pattern matching by the updating of shade templates even in the case where the shapes of templates stored and the moving objects to be followed undergo a change. The invention is thus easily realizable for recognition of vehicles turning to the right at crossings or the behaviour of human beings. In addition, templates are traced as partial templates, and separated and integrated in post-processing, so that objects of varying sizes can be easily recognized.

Another embodiment of the present invention will be described below with reference to the accompanying drawings.

FIG. **21** is a block diagram showing a configuration of a vehicle recognition system according to another embodiment of the present invention. The image of a road taken by a TV camera **1** or the like is applied to an image memory **3** through an A/D converter for converting an analog into a digital data. A shade image memory of about 8 bits (256 gradations) is used as the image memory **3** according to the present embodiment. This vehicle recognition system includes a shade template memory circuit **4** for storing shade templates of shade images (8 bits and 256 gradations) of a vehicle. The shade image memory **3** and the shade template memory circuit **4** are so configured as to scan the interior of an memory by an address processor **5**. The shade template memory circuit **4** has a plurality of shade templates which have stored therein shade images of various vehicles taken from various angles. The shade pattern matching circuit **6** is for matching between the image data **30** of the image memory **3** and the image memory **40** of the shade template memory circuit **4**, and executes the normalized correlation calculation as shown by Equation (1). This embodiment is configured with the template cut-out circuit **8**, the trace management table **9** and the separation/integration circuit **10** eliminated from the system shown in FIG. **1**.

Any method of correlation processing having a similar advantage may be employed with equal effect.

The operation of the image memory **3**, the scanning and shade pattern matching circuit **4** and the operation of the shade pattern matching circuit **6** are controlled by the CPU **7**. More specifically, the address processor **5** and the shade pattern matching circuit **6** are activated by the CPU **7**, an image address of Equation (1) is generated at the address processor **5**, the data on the related address of the shade template memory circuit **4** and the image memory **3** is read out, the data required for similarity calculation is determined at the shade pattern matching circuit **6**, and the similarity r(u, v) is calculated at the CPU **7**.

The shade pattern matching circuit **6** will be briefly explained. The data relating to the shade template is capable of being calculated in advance. At the time of similarity calculation, therefore, the data relating to the input image is calculated and transmitted to the CPU **7**. The data relating to the input image, in the case of Equation (1), is obtained at the shade pattern matching circuit **6** by the calculation of Equations (2) to (4).

A diagram for explaining the shade pattern matching against an input image is shown in FIGS. **22A** and **22B**. Assume that four vehicles **13** are in the view as an object of matching as shown in FIG. **22A**. Shade templates representing the color and size (shape) of the vehicles are required to be prepared. While scanning with the pattern matching effected with a shade template **T21** as shown in FIG. **22B**, for example, a coordinate associated with an increased similarity r(u, v) is searched for. A point P1 is determined as shown in FIG. **23A**. In similar manner, the scanning with shade templates **T22** to **T24** makes it possible to determine points P2 to P4 as shown in FIG. **23A**. As a result, once the coordinates of vehicle position at time point t and at time point t+Δt are determined as shown in FIG. **23B**, the instantaneous moving speed and direction of each vehicle can be calculated.

The advantage of the afore-mentioned normalized correlation processing is that to the extent that the pattern and the image of shade templates in registration are similar, a similarity is obtained to some degree even when brightness changes or a vehicle is hidden behind something (as in the case of vehicles superposed or hidden partially in the shadow of a building). More specifically, even a vehicle bearing a color similar to the brightness of the road surface can be recognized as a "vehicle" from the shape thereof. In conventional systems, the binary-coding operation at a certain threshold value makes it very difficult to recognize a vehicle of low contrast. The method according to the present embodiment, by contrast, permits easy extraction of a vehicle.

In recognizing the behaviour of a vehicle running along the road, full scanning for vehicle search as shown in FIG. **22B** is not always required. More specifically, in view of the fact that the moving range of a vehicle is limited to some degree, the next search range can be specified from the preceding behaviour of the vehicle. The limitation of the search range is executed in the same way as in the embodiment described above with reference to FIGS. **8** to **10A**, **10B** and Equations 5 to 8 and will not be explained again.

Now, explanation will be made with reference to FIGS. **24A** to **24D** about an example in which a vehicle is followed actually.

FIG. **24A** shows the case in which vehicles move upward in the screen. Vehicles are required to be followed sequentially by the images thereof entering the screen. For this purpose, a detection area is set at the lower part of the screen, and vehicle images entering this portion are followed upward. Several shade templates are prepared. First, a vehicle is detected in a search area. More specifically, the similarity processing is executed in the search area for each shade template. Assuming that vehicles are detected at coordinates **P1** and **P2** as shown in FIG. **24B** at time point t as a consequence, a following table is prepared as Table 1, in which the coordinates **P1** and **P2** are registered at Xold and Yold, respectively.

TABLE 1

					Conditions at time t						
flag	Xold	Yold	Tno	Timeold	x1	Y1	Time1	X2	Y2	Time2	Next search area
1	x0	y0	3	t	x0	y0	t	0	0	0	xs,ys,xe,ye
1	x10	y10	5	t	x10	y10	t	0	0	0	
.											
.											
.											

At the same time, the shade template number Tno and the time Timeold are registered. Since the initial states of following are involved, Xold, Yold and Timeold are registered at **X1**, **Y1** and Time**1** respectively, and "0" at X2, Y2 and Time2. X1, Y2 and Time1 represent the preceding coordinate and time, and X2, Y2 and Time**2** represent the present coordinate and time for following vehicles. Further, due to the initial stages, the preceding speed and direction of movement are not determined. As the next search area, therefore, the initial moving speed of "0" to maximum speed (150 km/h on an expressway, for example) and the initial change amount of the direction of movement of, say, 30 degrees, are set, with a moving range designated (xs, ys, xe, ye are calculated with Vminat 0 km/h, Vmax at 150 km/h, θ at zero degree and φ at 30 degrees). An image at time point t**1** is inputted, and the similarity is calculated with a shade template with Tno of "3" with respect to the search area for vehicle P**1**. As shown in Table 2, the point P**1**' of maximum similarity is substituted into the coordinate (X2, Y2).

This management makes it possible to execute the following of vehicles with ease.

FIGS. **25**, **26** and **27** are flowcharts showing specific steps of processing, in which FIG. **25** shows a main flow.

(1) First, shade templates are registered and the management table is initialized.

(2) An image is inputted, and vehicles are searched for in a detection area with respect to the particular image, thereby executing the following of vehicles.

The vehicle search in the detection area is executed as follows, as shown in FIG. **26**:

(1) The shade template number is initialized, and the matching processing executed by the template number i.

(2) If there is any coordinate with a similarity degree more than a threshold value, the maximum coordinate for such a similarity degree is determined, and the coordinate, the shade template number and the time are

TABLE 2

					Conditions at time t1						
flag	Xold	Yold	Tno	Timeold	x1	Y1	Time1	X2	Y2	Time2	Next search area
1	x0	y0	3	t	x0	y0	t	x1	y1	t1	xs',ys',xe',ye'
1	x1	y10	5	t	x10	y10	t	x11	y11	t1	
.											
.											
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Similar processing is executed also for the vehicle at point P2. In the second and subsequent executions, the moving speed can be determined. The moving speed V thus determined and the direction θ are used to determine and store the next search area by the method mentioned above. This is also the case with the processing at time point t**2**, which is expressed as in Table 3.

registered as Xol, Yold, Tno and Timeold respectively in the following (tracking) table.

(3) In the process, values of Xold, Yold and Timeold are stored in X1, Y1 and Time1, respectively.

(4) Then, a flag of the table is set and the next search area (initial value) is determined.

TABLE 3

					Conditions at time t2						
flag	Xold	Yold	Tno	Timeold	x1	Y1	Time1	X2	Y2	Time2	Next search area
1	x0	y0	3	t	x1	y1	t1	x2	y2	t2	xs',ys',xe',ye'
1	x1	y10	5	t	x11	y11	t1	x12	y12	t2	
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.											
.											

The above-mentioned processing is executed also for all the shade templates. The vehicle detection process is thus complete.

The processing for following vehicles is executed as shown in FIG. **27**.

(1) The counter of the following table is initialized. The pattern matching is effected by the shade template (Tno) with respect to the next table if the flag in the following table i is "0", and with respect to the search area if the flag is "1".

(2) If there is any similarity degree more than a threshold value, the coordinate of maximum similarity degree is extracted. The coordinate is stored at X**2**, Y**2** of the following table, the prevailing time at Time**2**.

(3) A search area for the next image is calculated from the moving speed and direction determined from X**1**, Y**1**, X**2**, Y**2**, and the search area is stored.

(4) After that, X**2**, Y**2** and Time**2** are copied at X**1**, Y**1** and Time**1** respectively.

The afore-mentioned operation is performed for all the vehicles with a set flag, thereby completing the vehicle-following processing.

Provision of a number of shade templates for detection of incoming vehicles would consume a very long time in vehicle search at a detection area in FIGS. **24**A to **24**D, with the result that moving objects, if high in speed, could not be detected one by one. This problem may be solved by either of the two countermeasures described below.

(1) To reduce the shade templates as far as possible.

(2) To prepare shade templates for following vehicles from an input image.

The method (1) will be explained. Shade templates of only "white/small", "black/small", "white/large" and "black/large" used for vehicles are insufficient in number. In the case where a white/small template is available, for instance, the vehicles, though all small in size, cannot be detected by the matching with patterns of different shapes due to variations including sedan, van, jeep and vehicle with loading space. It is, however, very time-consuming and unrealistic to store all types of shade templates for matching.

In view of this, a method of preparing shade templates will be explained with reference to FIGS. **28** to **30**. Assume that there are eight shade templates T(**1**) to T(**8**) prepared as shown in FIG. **28**. The similarity degree of each template in comparison with the others is checked by matching, say, template T(**1**) with the other shade templates. If there is any pair of similar templates, both the templates of the particular pair are used to prepare a new pattern of template, while the original one is discarded thereby to reduce the number of templates. In the case where pattern T(**1**) is similar to pattern T(**6**), and pattern T(**3**) to pattern T(**5**), for example, the images of both patterns T(**1**) and T(**6**) are averaged to prepare a pattern T'(**1**). Also, a pattern T'(**3**) is prepared by averaging the images of patterns T(**3**) and T(**5**).

As a result of combining images by determining the similarity once in the manner mentioned above, the shade templates are reduced to six as shown in FIG. **29**. By similar matching between the patterns shown in FIG. **29** and the initial shade templates T(**1**) to T(**8**) shown in FIG. **28**, new shade templates shown in FIG. **30** are synthesized, thereby reducing the total number of templates. If this process is repeated until the similarity degree larger than a certain threshold value is eliminated, the shade templates finally obtained meets the necessary minimum for extracting vehicles. The processing time is thus remarkably reduced. Instead of preparing a new shade template by averaging images as mentioned above, the maximum or minimum concentration of two images may be reserved.

Now, the method (2) will be explained. According to the method (2), shade templates are not prepared in advance. Instead, images to be followed are automatically cut out of an input image taken by way of TV camera, and are used as shade templates. In this case, as many templates as vehicles to be followed suffices.

This method will be explained with reference to FIGS. **31** to **33**. FIG. **31** shows a case in which a vehicle is moving upward in the screen (the dashed line defines lane areas). In order to follow this vehicle, an area sufficient covering the vehicle is cut out of the image at the lower part of the screen, and is used as a shade template as shown in FIG. **31**. If an image not covering the vehicle at the center of the area to be cut out is registered as a shade template as shown FIG. **32**, the subsequent following process is adversely affected. The concentration of the image thus cut out is checked for any deviation to periphery, and if need be, the position and size of the area to be cut out are changed.

Taking note of the fact that the vehicle pattern is laterally symmetric, the processing mentioned below is executed.

(1) The cumulative distribution of concentration along vertical direction of the cut-out image is determined (cumulative distribution of concentration along abscissa).

(2) The center of gravity xg and the variance σx of the concentration of the distribution thus obtained is determined.

(3) In similar fashion, the cumulative distribution of concentration is determined along horizontal direction of the image cut out (cumulative distribution of concentration along ordinate).

(4) The center of gravity yg and the variance σy of concentration of the distribution thus obtained are determined.

(5) With the concentration center of gravity xg, yg as a central coordinate, an area of the size given as

$$\Delta x = \alpha \cdot \sigma x$$

$$\Delta y = \alpha \cdot \sigma y$$

is cut out, where α is a constant (FIG. **33**).

(6) The processing mentioned above is executed again for the cut-out area and is repeated until the center-of-gravity coordinate and variance come to remain unchanged.

The aforementioned processing makes it possible to register a shade template of a minimum area (FIG. **34**) surrounding a vehicle. In the case where the concentration is sided in the end, the vehicle is assumed to be not covered completely in the screen, and the registration of the shade template is suspended (and reprocessed with an image inputted at the next time point).

The embodiments described above refer to the processing with a road viewed from right above. In actually taking a picture of a road, however, it is virtually impossible to photograph a road from right above. The inevitable result is taking a bird's-eye view of a road. In such a case, the road presents such a view that a vehicle, with the movement from T**1** to T**2** starting with time T**0**, appears the smaller the farther it runs away, as shown in FIG. **35**A. If a shade template is followed in the manner explained with reference to FIG. **31**, a vehicle appearing to be of the same size as the shade template could be detected but a far vehicle could not be detected and finally fails to be followed.

This inconvenience is overcome by updating the shade template while following the vehicle as shown in FIG. **35**B.

More specifically, when a point P0 is detected by a shade template, another shade template for the next search is prepared by use of an image proximate to the point **P0**. In this method, as in the method described above, the concentration center of gravity and variance may be used. The shade template thus newly registered is used for matching processing for the next search area thereby to determine the point **P1**. A shade template is prepared by using an image in the vicinity of the point **P1**. This process is sequentially executed, so that vehicles, even if changed in size, can be followed in versatile fashion. This method is based on the fact that the vehicle size rarely changes instantaneously.

A template may alternatively be prepared by linear coupling operation ($\alpha f+\beta g$, $\alpha+\beta=1$) or by determining an average ($(f+g)/2$) of the image (f) in the vicinity of a newly-detected vehicle position and the preceding template image (g).

If this technique is used, a vehicle can be followed easily by updating the shade template at the same time, unlike when using a single template in which case the following of a vehicle is suspended midway in measuring the number of vehicles turning to the right at an intersection, in view of the fact that the vehicle turning to the right changes its direction slowly, as shown in FIG. **12**. An alternative method consists in reducing the size of the shade template according to the vehicle size, i.e., according to the ratio determined by the ordinate of the vehicle position determined. In this method, however, the change only in size can be dealt with.

According to the present embodiment, as described above, the behaviour of vehicles, even if low in contrast or superposed, can be detected accurately by the shade pattern matching. Also, the updating of a shade template makes it possible to execute the following of a moving object by pattern matching even when the shape of the template stored or the moving object undergoes a change. Especially, easy recognition of a vehicle turning to the right at an intersection or the like is possible.

This embodiment is also applicable to the detection of a stationary vehicle (such as illegally parked) or management of a parking lot (detection of an occupied section).

Another embodiment of the present invention as applied to an abnormality detection system for a road, etc. will be explained.

A general configuration of the present embodiment is shown in FIG. **36**. An abnormality detection system **200** includes a plurality of image processing units **100-1**, **100-2** and **100-3** and a central overall determination section **22**. In order to grasp various abnormal phenomena, each of image processing units **100-1**, **100-2** and **100-3** includes a traffic flow measuring section **26** for collecting various information by processing input images of objects, an abnormal run monitor **14**, a stationary vehicle detector **16**, a congestion degree measuring section **18** and a local overall determination section **19** (**19-1**, **19-2**, **19-3**). The central overall determination section **22**, on the other hand, is for collecting data on each image processing unit and making an overall determination by spatial interpolation, for example.

The operation of each section will be briefly explained. The image processing unit **100** is inputted with an image (section **23**), extracts a background difference feature with respect to the image (section **24**), follows vehicles (section **25**), and measures the resulting traffic flow (number and speed of vehicles) (section **26**). Also, the frame feature of an input image is extracted (section **15**) and a stationary vehicle is detected (section **16**). In addition, features of spatial and temporal differentiations with respect to an input image are extracted (section **17**) and the degree of congestion is measured (section **18**). An overall decision is made on these results at the local overall determination section **19** (**20**, **21**) to determine the presence or absence of any abnormal phenomenon. At the same time as the abnormality determination at each unit, all the measurement information such as congestion degree and speed obtained at each unit are collected by the central overall determination section **22**, and after spatial interpolation, an abnormal phenomenon outside of the visual field of the camera is detected.

Each section will be described below in detail.

(1) Traffic flow measurement section

The traffic flow measurement data includes the vehicle speed and the number of vehicles passed. An example of the method for obtaining these data is shown in FIG. **37**. The steps for processing are described below.

The background image **30** stored in advance is removed from the input image f(t) **31** at time point t thereby to extract a vehicle.

The end coordinate of the vehicle image **32** extracted (as in the case where the vehicle is photographed from behind) is detected (**33**).

The above-mentioned steps **35** and **36** are executed with the image f(t+dt) sequentially obtained, and the position to which the end coordinate has moved is determined by the coordinate-following operation **37**.

The number of vehicles passed **38** and the speed **39** are measured from the coordinate change followed.

The vehicle flow within the visual field of the camera can be measured by this processing. It is possible to determine by monitoring this data that an abnormality has occurred, for example, when the vehicle speed has abnormally decreased.

When the end coordinate of a vehicle is extracted, the range of vehicle existence, i.e., the coordinates at the extreme right and left ends of the vehicle are measured at the same time in order to monitor for an abnormal run as described below.

(2) Abnormal run monitor section

A small fallen object or the like cannot be easily detected by the function of stationary vehicle detection described below. In the presence of a fallen object, however, the vehicle is normally driven avoiding the object, and therefore an abnormal running pattern is generated. This function is for monitoring such an abnormal running pattern. Many vehicles running in abnormal manner are liable to straddle the lane boundary, frequently change lanes or change the speed suddenly.

In order to detect such phenomena as mentioned above, the present invention uses the processing as shown in FIG. **38**. A road image is designated as **40**.

A vehicle is extracted from an input image as in the traffic flow measurement.

The various coordinates of the vehicle are determined from the vehicle image extracted. They include the distance ds to the coordinate at the extreme left end of the vehicle, the distance de to the coordinate at the extreme right end of the vehicle and the central coordinate.

Each vehicle is followed at the time of traffic flow measurement, and the change of the coordinates thereof is determined. As a result, the instantaneous speed and direction of movement are obtained.

After the above-mentioned processings, the respective data are reserved as an accumulated data as shown in FIGS. **39A** to **39C** for abnormality determination.

Accumulated data on the coordinates at the extreme left and right ends provide information to determine a range in which vehicles are running frequently within a lane as shown in FIG. **39A**. It is thus possible to determine that a

vehicle is running abnormally when the frequency of displacement from a normal drive range exceeds a predetermined threshold value.

Determination can also be made on whether the data on speed or direction of movement, if managed in similar fashion as shown in FIGS. **39**B and **39**C, frequently assumes an abnormal value.

(3) Function of stationary vehicle detection

In the case where there is any stationary vehicle present within the visual field of the camera, direct detection of the stationary object is more desirable than indirect measurement like the monitoring of an abnormal run. More specifically, a stationary object detectable by imaging (a stationary vehicle, a somewhat large fallen object, etc.) is detected directly.

A method of detecting a stationary object is shown in FIG. **40**. An outline of this processing is described below.

An image is inputted at predetermined time intervals dt as indicated by f(t− dt) **42** and f(t) **43**, and a background image **41** stored in advance is removed from each input image.

The images **44**, **45** from which the background has been removed have only a vehicle image remaining therein. A moving object is detected by use of these images. A method of detecting a moving object is by determining the speed as in the measurement of traffic flow. In the case under consideration, however, a moving object is detected by the features between image frames. More specifically, two images are subjected to a differentiation processing to extract a moving area (**46**).

The area from which a moving area image **46** is removed from an image lacking the background makes up a candidate image of a stationary object (**47**). Upon confirmation that the position of this object remains stationary, it is determined that there exists a stationary object as a final result (**48**).

A stationary object or a fallen object can be detected within the visual field of the camera by executing the above-mentioned processing.

(4) Function of congestion measurement

An abnormal phenomenon outside of the visual field of the TV camera is impossible to detect directly. In view of this, a phenomenon as a repercussion of an abnormality occurring outside of the camera which enters the visual field thereof, i.e., the congestion degree, is measured. In the case where the congestion degree assumes a value different from a normal one, it may be decided that some abnormality has occurred in the direction forward of the vehicle.

The congestion (traffic jam) degree may be measured by various methods. The method employed in the present invention uses no traffic flow data but is based on the macroscopic measurement of the number and speed of vehicles taken by such expressions as "vehicles are many", "vehicles are few", "vehicle speed is high" or "vehicle speed is low" as shown in FIG. **41**. This is due to the fact that with the intensification of vehicle congestion, the images taken by the TV camera are superposed one on another, thereby making impossible the microscopic measurement of the number and speed of vehicles. Especially, vehicles appear superposed very often in a tunnel where TV cameras are installed at low level.

The processing will be described briefly below.

An input image f(t) **50** is differentiated (with a profile perpendicular to the running direction extracted) (spatial differentiation **51**), and the feature amount relating to the vehicle quantity is calculated (**52**). In the case under consideration, a differentiated image is binary-coded and the number of vehicle profiles is determined.

Further, an image f(t+dt) **53** is inputted at predetermined time intervals dt (say, 200 ms), and a difference image is determined for each picture element of f(t) **50** and f(t+dt) **53** (temporal differentiation **54**). If a vehicle is moving, a differentiation image in some form or other appears. In the case where the vehicle remains stationary, on the other hand, no information is obtained. The feature amount (such as width) of an image obtained from the differentiation image is therefore determined as a data relating to speed (**55**).

The feature amounts relating to the vehicle quantity and speed mentioned above are applied to a decision function **56** engaged in learning in advance for calculation of the congestion degree. A neural network is used for the decision function under consideration.

An abnormal phenomenon can be monitored by the feature amount like the vehicle quantity or speed as well as by the congestion degree determined from the above-mentioned processing.

(5) Local overall determination section

The processing by the local overall determination section is executed mainly for improving the reliability of the information obtained from the functions of "traffic flow measurement", "measurement of abnormal run", "detection of stationary vehicles" and "congestion degree measurement". Abnormal phenomena include local ones such as stationary vehicles (accidents) and overspeed, and abnormalities covering wide areas like traffic congestion. An alarm should be issued against a local abnormality at the time point of detection by each image processing unit. Nevertheless, the problem of measurement accuracy makes it necessary to check the measurement result. Also, the manner in which an alarm is issued against a congestion apparently covering a wide range depends on whether the particular congestion is confined within the visual field of the camera or covers all the measurement points. As a result, information on an abnormality covering a wide range (congestion degree, measurement result of traffic flow, etc.) is sent to a host system to make an overall decision (determination).

The information applied to the local overall determination section includes:

Traffic flow: Speed is high or low, traffic volume large or small

Abnormal run: Frequent or infrequent overspeed, frequently or infrequently displaced from normal running course

Stationary vehicle: Presence or absence

Congestion degree: high, middle or low

Of these information, local abnormalities relate to whether a case of overspeed or stationary vehicle is detected or not. As to the overspeed, a contradictory data indicating an overspeed at the time of congestion measured by the abnormal run function is considered impossible and is cancelled. The relationship between the measurement result of the congestion measurement function and the speed information is thus checked and a contradictory data is cancelled to prevent an overalarm. The information obtained in detecting a stationary vehicle, however, is reliable and may be used to issue an alarm immediately upon detection.

If the degree of an error developed by the speed data measured in accordance with the congestion level is grasped in advance, on the other hand, the speed data can be corrected in accordance with the congestion degree determined. This is also the case with the number of vehicles.

The local overall decision section checks for a data contradiction, and transmits information to a central determination section **22** as a host system, while at the same time controlling the information on the presence of a stationary vehicle or an abnormal run as determined under a condition

allowing accurate speed measurement ("unbusy state") in such a manner as to permit an immediate alarm output.

(6) Central overall determination section

In the event that TV cameras are installed at intervals of 200 m, for example, the range actually measurable by imaging covers only about one half of this distance. An abnormal phenomenon occurring at a position not monitored by imaging, therefore, is required to be subjected to interpolation (estimation) from the result of processing of adjacent TV cameras.

An interpolation processing described below is effected according to the present invention.

(i) Spatial interpolation

The spatial interpolation at the central overall determination section is to spatially grasp and interpolate the result of processing the image of each TV camera. The spatial interpolation enables a determination on whether a given congestion is a chronic one or due to an accident or a stationary vehicle, or an estimation of any abnormality in an area not covered by the camera. For example, the congestion degree at each ground point is plotted two-dimensionally as shown in FIG. **42**, and it is decided that some abnormality has occurred at or in the vicinity of a point where the congestion degree has considerably changed as compared with the neighbouring conditions. In FIG. **42**, the congestion degree of the left lane is low, while that of the opposite lane (passing lane) is high. It is, therefore, estimated that abnormally many vehicles change lanes in this section.

More specifically, the congestion degree obtained from each image processing unit is studied in overall fashion. It is decided that an abnormality is caused outside of the measurement section if traffic is congested in all sections, or that the congestion is a chronic one if the traffic congestion is limited to part of the measurement range, so that an abnormality decision is made only when traffic is congested only in part of the measurement range.

All the information acquired are processed as data, and any part where the congestion degree is locally different is searched for. If there is found any such part, an abnormality decision is made. Otherwise, a decision is made that the traffic is normal. The data is analyzed either by a general waveform (one-dimensional data on congestion degree with respect to ground point) analysis technique or by a method in which a waveform is directly inputted to a neural network to detect a change point.

Objects of data analysis may include not only the congestion degree but also the data on abnormally running vehicles monitored (lane data, speed data, etc.). It is possible to make an abnormality decision when vehicles are displaced from a normal course only at a part of the range.

In general, an attendant observes the monitor screen to check for any abnormal phenomenon. If a spatial graph as shown in FIG. **42** is indicated to present the result of automatic decision to the monitor attendant, the conditions of the entire measurement range become easy to grasp.

An abnormality is an invisible phenomenon, and therefore the type thereof cannot be specified, although a decision as to the presence or absence of an abnormality is possible. The coordinate distribution, speed distribution, etc. of vehicles, instead of the congestion degree plotted in FIG. **42**, may be spatially determined.

(ii) Temporal interpolation

The data measured at each image processing unit is collected and managed in time series as shown in FIG. **43**. A decision is made on the time of occurrence or on whether the abnormalities are of primary nature (such as the effect of a noise specific to the image processing) or of sustaining nature. This decision is made by waveform analysis as in the case of the spatial interpolation described above.

As a result, a noise-related abnormality is removed for an improved system reliability. Also, the indication to the monitor attendant facilitates the grasping of a chronological change as in the case of spatial interpolation.

An example of hardware configuration for realizing the abnormal phenomenon detection mentioned above is shown in FIG. **44**. Video images from a plurality of TV cameras **60** installed appropriately are applied to image processing units **100**, which execute "traffic flow measurement", "monitoring of abnormally-running vehicles", "detection of stationary vehicles" and "congestion degree measurement", and transmit the result of the executions to a central overall determination section **22** as a host system.

Each of the image processing units **100** includes an A/D converter **70** for converting a video signal of the TV camera **60** into a digital signal, an image memory **71** for storing the resulting data, an image processor **72** for processing the data of the image memory **71**, a data output section **73** for transmitting the data to the central overall determination section **22**, and a CPU **74** for controlling these devices, as shown in FIG. **45**. The image processor **72** is capable of executing the inter-image operations such as subtraction and addition of images or a spatial sum-of the products operation such as differentiation, binary coding or histogram processing. The local overall decision is processed at the CPU **74**.

The central overall determination section **22**, as shown in FIG. **46**, includes an interface section **74** for transmitting and receiving a data with each image processing unit **100** not shown, a data accumulator **75** for reserving the data thus obtained, and a data analyzer **76** for subjecting the accumulated data to spatial and time interpolation.

According to the present embodiment, as described above, various abnormal phenomena are capable of being detected by the functions of "traffic flow measurement", "detection of abnormally-running vehicles", "detection of stationary vehicles", "congestion degree measurement" and "inter-camera interpolation".

In addition to the conditions in the tunnel, as described above, the road conditions in general can of course be monitored with equal effect according to the present invention.

We claim:

1. An object recognition system for photographing an object by a TV camera and recognizing movement of the object by processing images from the TV camera, comprising:

a template extracting circuit extracting partial templates from an image of an object;

a following means for following the object by correlation calculation between the partial templates and an input image; and

means for separating/integrating the partial templates on a basis of a selected one of a history of coordinates followed and a knowledge relating to the object.

2. An object recognition system according to claim **1**, wherein said template extracting circuit extracts images of a plurality of partial areas formed on an object-incoming side of an input image as templates.

3. An object recognition system according to claim **1**, wherein said template extracting circuit extracts an input image corresponding to an area having selected one of a large spatial frequency feature and a large time frequency feature as a template of predetermined size.

4. An object recognition system according to claim **1**, wherein the template extracting circuit extracts an area

representing a similarity of a moving object from an input image and extracts an input image corresponding to a particular area as said templates.

5. An object recognition system according to claim 1, wherein said separation/integration circuit separates or integrates templates having a similar speed and direction of movement of an object on a basis of the trace of movement determined for each template.

6. An object recognition system according to claim 1, wherein said following means comprises:

a means for learning a past behavior pattern by a neural network;

a means for predicting future behavior from the past behavior pattern and a present behavior pattern; and

a means for determining a range of correlation calculation with respect to templates.

7. An object recognition system according to claim 1, further comprising a template updating circuit for updating a template image stored by use of an input image.

8. An object recognition system according to claim 7, wherein the template updating circuit matches patterns between an input image f(t) at time point t and a template g, and in a case where a coordinate P with a similarity degree larger than a predetermined threshold value is determined, an image in the vicinity of the coordinate P of input image f(t) is registered newly as a gray scale template g'.

9. An object recognition system according to claim 7, wherein the template updating circuit matches patterns between an input image f(t) at time point t and a template g, and in a case where a coordinate P with a similarity degree larger than a predetermined threshold value is determined, a new template expressed by $g'=\alpha f'(t)+\beta g$ (σ, β: constants) using an image f'(t) in the vicinity of the coordinate P of all the input images f(t) is registered.

10. An object recognition system for photographing an object by a TV camera and recognizing movement of the object by processing input images from the TV camera, comprising:

a template extracting circuit extracting a plurality of images in a template area of predetermined size from an input image f(t) at a time point t;

a template memory circuit storing a plurality of images obtained by the template extracting circuit;

a pattern matching circuit determining a movement point of each template by shade pattern matching between each template stored in the template memory circuit and the input images at incrementing time points obtained from the TV camera;

a trace management table storing a relationship between a time point and a movement point for each gray scale template obtained at the gray scale pattern matching circuit; and

a separation/integration circuit deciding which templates represent an image of a same object by use of the trace management table.

11. A system for measuring an intersection traffic flow comprising:

a template extracting circuit extracting a plurality of images of a template area of predetermined size from an image at time point t;

a gray scale template memory circuit storing a plurality of templates obtained with the template extracting circuit;

a pattern matching circuit matching patterns between each of the templates stored in said template memory circuit and input images at time points (t+dt), (t+2dt), . . . (t+ndt) (n: integral number) obtained from a TV camera and determining a movement point of each of said templates;

a template updating circuit sequentially updating the templates of said template memory circuit using an input image;

a trace management table storing a relationship between a time point and a moving point for each template obtained with the pattern matching circuit;

a separation/integration circuit deciding on which templates represent a same object by use of the trace management table; and

a traffic parameter measurement section measuring a number and speed of vehicles passed, a number of vehicles turned to a right/left by following a vehicle position obtained.

12. A vehicle recognition system for photographing a road by a TV camera and recognizing movement of vehicles by processing images from the TV camera, comprising:

a template memory circuit for storing several types of vehicles images as images in advance; and

a pattern matching circuit for determining a vehicle position within an input image by pattern matching between the templates stored in the template memory circuit and the input image obtained from the TV camera.

13. A vehicle recognition system according to claim 12, further comprising a template pattern preparation circuit having a plurality of template patterns T(0) to T(n) for determining a similarity degree between the template patterns and for preparing a new template pattern from patterns similar to each other.

14. A vehicle recognition system for photographing a road by a TV camera and recognizing vehicle movement by processing images from the TV camera, comprising:

a template extracting circuit for extracting an image pattern corresponding to a vehicle as a template from an input image obtained by the TV camera;

a template memory circuit for storing a template obtained with the template extracting circuit;

a pattern matching circuit for determining a vehicle position within a subsequent input image by pattern matching between the template stored in the template memory circuit and said subsequent input image; and

a template extracting circuit for cutting out an area of predetermined size from an image entered by a vehicle, determining an extracting position in such a manner as to locate the vehicle at a center thereof from features of an extracted image, and registering an input image of the extracting position and a vicinity thereof as templates.

15. A traffic flow measurement system for photographing a road by a TV camera and recognizing vehicle movement by processing images from the TV camera, comprising:

a template memory circuit storing a vehicle image corresponding to a vehicle as a template

a pattern matching circuit pattern matching between the template stored in the template memory circuit and a subsequent input image obtained from the TV camera; and

a vehicle speed and direction determining means for determining a vehicle position by pattern matching with respect to the input image at a given time point, further determining the vehicle position with respect to the input image at a given time point and determining

at least a speed and direction of movement of vehicles, in accordance with a change in coordinates of determined positions;

wherein said vehicle speed and direction determining means determines a range of pattern matching of the template against the input image $f(t+\Delta t)$ at a time point $t+\Delta t$ on a basis of the speed and direction of movement obtained from a result of pattern matching of images $f(t-\Delta t)$, $f(t)$ at time points $(t-\Delta t)$ and t respectively.

16. A pattern matching system for executing pattern matching between a template and an input image, comprising:

a template memory circuit storing a pattern of an image;

a pattern matching circuit pattern matching between a template stored in the template memory circuit and a subsequent input image obtained from a TV camera; and

a template updating circuit sequentially updating the templates of the template memory circuit using input images;

wherein pattern matching is effected with a given template g against an input image f(t) at time point t, and in a case where a coordinate P is determined to have a similarity degree obtained by pattern matching larger than a predetermined threshold value, an input image f(t) of the coordinate P and a vicinity thereof is registered as a new template g'.

17. A pattern matching system for executing pattern matching between a template and an input image, comprising:

a template memory circuit storing a pattern of an image;

a pattern matching circuit pattern matching between a template stored in the template memory circuit and a subsequent input image obtained from a TV camera; and

a template updating circuit sequentially updating the templates of the template memory circuit using input images;

wherein pattern matching is effected with an input image f(t) at a time point t against a template g, and in a case where a coordinate P is determined to have a similarity degree larger than a predetermined threshold value, an input image f(t) of the coordinate P and a vicinity thereof is used to register a template expressed as $g'=\alpha f'(t)+\beta g$ (α, β: constants) as a new template.

18. A pattern matching system for executing pattern matching between a template and an input image, comprising:

a template memory circuit storing a pattern of an image;

a pattern matching circuit pattern matching between a template stored in the template memory circuit and a subsequent input image obtained from a TV camera; and

a template updating circuit sequentially updating the templates of the template memory circuit using input images;

wherein a template is updated while changing a template size in accordance with a size of an object.

19. A system for following, in a picked-up image, a moving object of a shape and size changing with the direction of movement and distance from the image pick-up means, comprising:

a template memory circuit for storing a pattern of an image of the moving object as a template;

a pattern matching circuit for determining a position of the moving object by pattern matching between the template stored in the template memory circuit and an input image obtained from the image pick-up means; and

a template updating circuit for preparing an updated template for a next pattern matching from the template of the moving object cut out of a present input image and a preceding template of the moving object and storing the updated template in the template memory circuit.

20. An abnormality detection system for detecting an abnormal phenomenon by photographing a road with a plurality of TV cameras installed at predetermined intervals on the road and processing images from the TV cameras, comprising:

a plurality of image processing units including a local overall decision section having functions of processing images from the TV cameras and measuring a speed and number of vehicles, monitoring abnormally-running vehicles, detecting a stationary object and measuring a congestion degree, and correcting data on the speed and number of vehicles and the abnormally-running vehicle monitor functions in accordance with the congestion degree; and

a central overall decision section making an overall decision by spatial and temporal interpolation of a result of measurement at the image processing units.

21. An abnormality detection system according to claim **20**, wherein the central overall decision section includes a means for collecting several types of information from a plurality of image processing units, a spatial interpolation means for grasping said information spatially and making an abnormality decision only when said information undergoes a local change, and a time interpolation means for grasping a plurality of information in time series and deciding on an initial time of abnormality occurrence and an instantaneous abnormality.

22. An abnormality detection system for detecting an abnormal phenomenon by photographing a road with a TV camera and by processing images from the TV camera, comprising:

a local overall decision section having functions of measuring a speed and number of vehicles, monitoring abnormally-running vehicles, detecting a stationary object and measuring a congestion degree for correcting data on the speed and number of vehicles and abnormally-running vehicle monitor functions in accordance with the congestion degree;

wherein the function of monitoring abnormally-running vehicles is performed using a means for extracting vehicles from an input image, a means for determining an extreme left coordinate, extreme right coordinate and end coordinate of vehicles from a vehicle image extracted, a means for calculating an amount of vehicle movement from coordinates thus determined and an image inputted at a next time point, a means for accumulating resulting coordinate values and speed and direction of movement for a number of vehicles involved, and means for making an abnormality decision when coordinates exceed a threshold value of a frequency of vehicles running outside a predetermined position, a frequency of vehicles running at other than a predetermined speed and a frequency of vehicles moving in other than a predetermined direction, respectively.

23. An abnormality detection system for detecting an abnormal phenomenon by photographing a road with a TV

camera and by processing images from the TV camera, comprising:

a local overall decision section having functions of measuring a speed and number of vehicles, monitoring abnormally-running vehicles, detecting a stationary object and measuring a congestion degree for correcting data on the speed and number of vehicles and abnormally-running vehicle monitor functions in accordance with the congestion degree;

wherein the local overall decision section cancels a speed data obtained with a high congestion degree, when the speed data is higher than a predetermined threshold value.

24. An abnormality detection system for detecting an abnormal phenomenon by photographing a road with a TV

camera and by processing images from the TV camera, comprising:

a local overall decision section having functions of measuring a speed and number of vehicles, monitoring abnormally-running vehicles, detecting a stationary object and measuring a congestion degree for correcting data on the speed and number of vehicles and abnormally-running vehicle monitor functions in accordance with the congestion degree;

wherein the local overall decision section corrects data on the speed and the number of vehicles determined, in accordance with the congestion degree.

* * * * *

reduced. An article published several years later by Knudsen opined that the Carlisle technique does not yield appreciable improvement in bubble oscillation suppression. However, the article did not test the Carlisle technique under comparable conditions because Knudsen did not use Carlisle's spacing or seismic source. Furthermore, where the Knudsen model most closely approximated the patent technique there was a 30% reduction of the secondary pressure pulse. On these facts, the court found that the Knudsen article would not have deterred one of ordinary skill in the art from using the Carlisle patent teachings.).

III. FACT THAT REFERENCES CAN BE COMBINED OR MODIFIED **>MAY NOT BE< SUFFICIENT TO ESTABLISH *PRIMA FACIE* OBVIOUSNESS

The mere fact that references can be combined or modified does not render the resultant combination obvious unless **>the results would have been predictable to one of ordinary skill in the art. *KSR International Co. v. Teleflex Inc.*, 550 U.S. ___, ___, 82 USPQ2d 1385, 1396 (2007)("If a person of ordinary skill can implement a predictable variation, § 103 likely bars its patentability. For the same reason, if a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill.").<

IV. *>MERE STATEMENT< THAT THE CLAIMED INVENTION IS WITHIN THE CAPABILITIES OF ONE OF ORDINARY SKILL IN THE ART IS NOT SUFFICIENT BY ITSELF TO ESTABLISH *PRIMA FACIE* OBVIOUSNESS

A statement that modifications of the prior art to meet the claimed invention would have been "'well within the ordinary skill of the art at the time the claimed invention was made'" because the references relied upon teach that all aspects of the claimed invention were individually known in the art is not sufficient to establish a *prima facie* case of obviousness without some objective reason to combine the teachings of the references. *Ex parte Levengood*, 28 USPQ2d 1300 (Bd. Pat. App. & Inter. 1993). **">[R]ejections on obviousness cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.'" *KSR*, 550 U.S. at ___, 82 USPQ2d at 1396 quoting *In re Kahn*, 441 F.3d 977, 988, 78 USPQ2d 1329, 1336 (Fed. Cir. 2006).<

V. THE PROPOSED MODIFICATION CANNOT RENDER THE PRIOR ART UNSATISFACTORY FOR ITS INTENDED PURPOSE

If proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there is no suggestion or motivation to make the proposed modification. *In re Gordon*, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984) (Claimed device was a blood filter assembly for use during medical procedures wherein both the inlet and outlet for the blood were located at the bottom end of the filter assembly, and wherein a gas vent was present at the top of the filter assembly. The prior art reference taught a liquid strainer for removing dirt and water from gasoline and other light oils wherein the inlet and outlet were at the top of the device, and wherein a pet-cock (stopcock) was located at the bottom of the device for periodically removing the collected dirt and water. The reference further taught that the separation is assisted by gravity. The Board concluded the claims were *prima facie* obvious, reasoning that it would have been obvious to turn the reference device upside down. The court reversed, finding that if the prior art device was turned upside down it would be inoperable for its intended purpose because the gasoline to be filtered would be trapped at the top, the water and heavier oils sought to be separated would flow out of the outlet instead of the purified gasoline, and the screen would become clogged.).

"Although statements limiting the function or capability of a prior art device require fair consideration, simplicity of the prior art is rarely a characteristic that weighs against obviousness of a more complicated device with added function." *In re Dance*, 160 F.3d 1339, 1344, 48 USPQ2d 1635, 1638 (Fed. Cir. 1998) (Court held that claimed catheter for removing obstruction in blood vessels would have been obvious in view of a first reference which taught all of the claimed elements except for a "means for recovering fluid and debris" in combination with a second refer-

ence describing a catheter including that means. The court agreed that the first reference, which stressed simplicity of structure and taught emulsification of the debris, did not teach away from the addition of a channel for the recovery of the debris.).

VI. THE PROPOSED MODIFICATION CANNOT CHANGE THE PRINCIPLE OF OPERATION OF A REFERENCE

If the proposed modification or combination of the prior art would change the principle of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims *prima facie* obvious. *In re Ratti*, 270 F.2d 810, 123 USPQ 349 (CCPA 1959) (Claims were directed to an oil seal comprising a bore engaging portion with outwardly biased resilient spring fingers inserted in a resilient sealing member. The primary reference relied upon in a rejection based on a combination of references disclosed an oil seal wherein the bore engaging portion was reinforced by a cylindrical sheet metal casing. Patentee taught the device required rigidity for operation, whereas the claimed invention required resiliency. The court reversed the rejection holding the "suggested combination of references would require a substantial reconstruction and redesign of the elements shown in [the primary reference] as well as a change in the basic principle under which the [primary reference] construction was designed to operate." 270 F.2d at 813, 123 USPQ at 352.).

2143.02 Reasonable Expectation of Success Is Required [R-6]

>A rationale to support a conclusion that a claim would have been obvious is that all the claimed elements were known in the prior art and one skilled in the art could have combined the elements as claimed by known methods with no change in their respective functions, and the combination would have yielded nothing more than predictable results to one of ordinary skill in the art. *KSR International Co. v. Teleflex Inc.*, 550 U.S. ___, ___, 82 USPQ2d 1385, 1395 (2007); *Sakraida v. AG Pro, Inc.*, 425 U.S. 273, 282, 189 USPQ 449, 453 (1976); *Anderson's-Black Rock, Inc. v. Pavement Salvage Co.*, 396 U.S. 57, 62-63, 163 USPQ 673, 675 (1969); *Great Atlantic & P. Tea Co. v. Supermarket Equipment Corp.*, 340 U.S. 147, 152, 87 USPQ 303, 306 (1950).

I. < OBVIOUSNESS REQUIRES ONLY A REASONABLE EXPECTATION OF SUCCESS

The prior art can be modified or combined to reject claims as *prima facie* obvious as long as there is a reasonable expectation of success. *In re Merck & Co., Inc.*, 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986) (Claims directed to a method of treating depression with amitriptyline (or nontoxic salts thereof) were rejected as *prima facie* obvious over prior art disclosures that amitriptyline is a compound known to possess psychotropic properties and that imipramine is a structurally similar psychotropic compound known to possess antidepressive properties, in view of prior art suggesting the aforementioned compounds would be expected to have similar activity because the structural difference between the compounds involves a known bioisosteric replacement and because a research paper comparing the pharmacological properties of these two compounds suggested clinical testing of amitriptyline as an antidepressant. The court sustained the rejection, finding that the teachings of the prior art provide a sufficient basis for a reasonable expectation of success.); *Ex parte Blanc*, 13 USPQ2d 1383 (Bd. Pat. App. & Inter. 1989) (Claims were directed to a process of sterilizing a polyolefinic composition with high-energy radiation in the presence of a phenolic polyester antioxidant to inhibit discoloration or degradation of the polyolefin. Appellant argued that it is unpredictable whether a particular antioxidant will solve the problem of discoloration or degradation. However, the Board found that because the prior art taught that appellant's preferred antioxidant is very efficient and provides better results compared with other prior art antioxidants, there would have been a reasonable expectation of success.).
>

II. < AT LEAST SOME DEGREE OF PREDICTABILITY IS REQUIRED; APPLICANTS MAY PRESENT EVIDENCE SHOWING THERE WAS NO REASONABLE EXPECTATION OF SUCCESS

Obviousness does not require absolute predictability, however, at least some degree of predictability is required. Evidence showing there was no reasonable expectation of success may support a conclusion of

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09/823,509	03/29/2001	Dennis Sunga Fernandez	84022.0137	8530

86244 7590 11/19/2009

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EXAMINER	
VO, TUNG T	
ART UNIT	**PAPER NUMBER**
2621	
NOTIFICATION DATE	**DELIVERY MODE**
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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

dbarker@swlaw.com
landerson@swlaw.com
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Office Action Summary	**Application No.** 09/823,509	**Applicant(s)** FERNANDEZ ET AL.	
	Examiner Tung Vo	**Art Unit** 2621	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *03* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *07/31/2009*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *24-33 and 39-53* is/are pending in the application.

4a) Of the above claim(s) *1-23 and 34-38* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *24-33 and 39-53* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *29 March 2001* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. Claims 24-32, 39-40, and 42-50 are rejected under 35 U.S.C. 103(a) as being unpatentable over Everett, Jr. et al. (US 5,202,661) in view of Hyuga (US 5,818,733).

Re claims 24, 27, and 31, Everett teaches a system (figures 1, 2, 4, and 6) comprising:

a communicator *(16 and 20 of fig. 1, see also 16 and 20c of fig. 2)* configured to receive first data associated with an object *(note the fixed sensor system, 12 of fig. 1, detects the presence of an intruder that is considered as the first data associated with an object; col. 6, lines 24-40; col. 22, lines 35-50; col. 28, lines 50-64)* and second data associated with the object *(note the mobile sensor, 19 of fig. 2, detects the presence of the object that is considered as second data associated with the object; col. 13, lines 5-14; col. 14, lines 1-14, 20-29; 14, line 55-col. 15, line 7)*, wherein the first data is received from a fixed detector configured to detect the first data *(12 of fig. 2, the fixed sensor system)*, and wherein the second data is received from a mobile target unit *(18 of fig. 1, the mobile robot, fig. 6)* comprising a sensor *(19 of fig. 1, the mobile sensor system, see figure 4 for more details)* configured to detect the second data; and

a processor (14 of figs. 1 and 2) configured to correlate the first data and the second data to generate object location information *(col. 2, lines 44-64, col. 3, lines 35-42, 49-56; col. 24, lines 39-col. 25, line 4; col. 28, lines 50-65, note Cross correlation between the fixed sensor system, 12 of fig. 2, and the mobile sensor system, 19 of figs. 1 and 4, to determine an intruder at position (X, Y) as object location information; wherein the (X,Y) position of the intruder depicted in a floor plan map, col. 29, lines 5-9).*

It is noted that Everett teaches that the mobile target unit has the propulsion module (416 of fig. 6) for moving the mobile target unit, and the propulsion module (426 of fig. 6) carried the camera and other elements as shown in figure 6, so this would obviously suggest that the mobile target unit includes a vehicle (416 and 422 of fig. 6) to move the mobile target unit.

However, Everett does not particularly disclose wherein the mobile target unit is at least one of: mounted in the object, mounted on the object, carried in the object, or carried on the object, and the object is a vehicle as claimed.

Hyuga teaches the mobile target unit (1 of fig. 2) is at least one of: mounted in the object (the mobile unit is carried by said sender or player or user), mounted on the object, carried in the object, or carried on the object (1 of fig. 2, the mobile unit can be held by the golf player, fig. 4, and carried on the golf cart, 29 of fig. 2) and the object is a vehicle (the golf cart, 29 of fig. 2).

Therefore, taking the teachings of Everett and Hyuga as whole, it would have been obvious to one of ordinary skill in the art to modify the teachings of Hyuga into the system of Everett for the same purpose of generating the accuracy object location to improve monitoring object.

Re claim 25, Everett further teaches wherein the mobile target unit *(18 of fig. 1, the mobile robot)* comprises a locator unit *(402 of fig. 4, note the local processor, 402 of fig. 4, passes required position and sonar information to the host computer, col. 7, lines 63-col. 8, lines 25)* configured to determine a target unit location *(Note the local processor receives X-Y position and heading from processor, 417 of fig. 4, of propulsion module, 416 of fig. 4, which is considered as a determined a target location)*, the communicator (16, 20a, and 20c of fig. 2) being further configured to receive the target unit location *(note the local processor, 402 of fig. 4, passes required positional and sonar information to the host computer, 14 of fig. 1)*, the processor (14 of fig. 1) being further configured to determine whether the mobile target unit is within a range of the fixed detector *(fig. 14, A-B indicates the mobile robot will be travel, so the mobile robot is within the range of the fixed sensor system; col. 3, lines 9-24)*.

Re claim 26, Everett further teaches wherein the object location information comprises at least one of object trajectory information *(col. 2, lines 34-39, the intruder's report is considered as object trajectory information)* or object speed information *(note the robot's mean forward velocity is adjusted as a function of range to the intruder, which means the mobile robot enables to determine the object speed information so that the mobile robot to follow the intruder, col. 29, lines 15-23)*; and the fixed detector provides an image of the object (12g1 of fig. 2, the video camera captures an image of the intruder).

Re claim 28, Everett further teaches a database *(Data stored in the history file is considered as database, col. 23, lines 40-55, col. 23, line 65-col. 24, line 18)* configured to maintain a plurality of current positions associated with at least one of a plurality of sensors, a plurality of mobile target units, or a plurality of objects.

Re claim 29, Everett further teaches wherein the mobile target unit comprises an accelerometer *(417 of fig. 4, note velocity control and acceleration/deceleration ramping are performed by processor, 417)* configured to provide data indicative of movement of the object to facilitate generating the object location information.

Re claim 30, Everett further teaches wherein: the object is an identified *good (Note the area under surveillance by the fixed and mobile sensors is considered as an identified good, col. 21, line 64-col. 22, line 2)*; the mobile target unit *(18 of fig. 2, the mobile robot)* comprises a radio-frequency identification device *(20b1 and 20b2 of fig. 2)*; and the fixed detector *(12 of fig. 2)* comprises a camera *(12g1 of fig. 2)* for observing the identified good *(the area under surveillance)*, to facilitate thereby enabling the sensor (19 of fig. 4) and the fixed detector (12 of fig. 2) to provide corroborative surveillance of the identified good *(col. 22, lines 35-50, see also col. 29, lines 1-9)*.

Re claim 39, Everett further teaches wherein the mobile target unit *(18 of fig. 1, the mobile robot)* comprises a locator unit (402 of fig. 4) coupled to determine a target unit location (col. 8, lines 8-25), the second data comprising the target unit location (col. 8, lines 8-25).

Re claim 40, Everett further teaches wherein the correlating the first data and the second data comprises determining compliance with a scheduled object activity (function of time, col. 13, lines 1-13).

Re claim 42, Everett further teaches a plurality of detectors (12g1 of figs. 2 and 4) each having a corresponding observation range *(12g1 of fig. 1, note the video camera, 12g1 of fig. 2, has a corresponding to observation range)*, wherein at least one of the plurality of detectors is selected to observe the object *(12g1 of fig. 4, the video camera , 12g1, follows the intruder)*, the

fixed detector (12g1 of fig. 2, col. 29, lines 1-9) being selected in response to the processor's correlation of the first data and the second data (col. 28, lines 58-64).

Re claim 43, Everett further teaches wherein the first data comprises at least one of an image of the object *(12g1 of fig. 2, the video camera captures image of the intruder)* or an identifier associated with the object.

Re claim 44, Everett further teaches wherein the first data comprises a plurality of images of the object captured at different times *(Note video signal from the video camera, 12g1 of fig. 2, have images of the object at different times).*

Re claim 45, Everett further teaches wherein the second data comprises at least one of an image of the object *(e.g. 19h of fig. 6, the video camera captures image of the intruder)* or an identifier associated with the object.

Re claim 46, Everett further teaches wherein the second data comprises a plurality of images of the object captured at different times *(note the video camera, 19h of fig. 6, inherently captures images of the intruder at different times).*

Re claim 47, Everett further teaches wherein the object location information is determined at least in part based on a fixed detector location *(e.g. 12 of fig. 2).*

Re claim 48, Everett further teaches wherein the object location information is determined at least in part based on a mobile target unit location *(18 of fig. 2).*

Re claims 32 and 49 , Everett further teaches a movement module *(col. 28, line 55-57, note the threat level is sufficient for the software(the software is performed by the computer is considered as a movement module) to activate secondary sensors, and the ultrasonic motion detection system, 19f of fig. 4, is enabled)* configured to activate a second fixed detector *(note the*

secondary sensors are activated) in response to the object location information *(Note thread level includes the object location information)*, wherein the fixed detector (e.g. 12e of fig. 2) is further from the second fixed detector (e.g. 19e of fig. 4) than from a third fixed detector (12d of fig. 2).

3. Claims 24-33 and 39-53 are rejected under 35 U.S.C. 103(a) as being unpatentable over Moengen (US 6,373,508).

Re claims 24 and 31, Moengen teaches a system (figs. 1 and 2) comprising:

a communicator (M, BL, and Q of fig. 2) configured to receive first data *(e.g. D1 and K1 of fig. 1, note transponders are also preferably provided both in the position detectors and the cameras, col. 12, lines 25-31)* associated with an object *(a natural object N, col. 3, lines 37-42)* and second data associated with the object *(mobile cameras are used, col. 12, lines 27-31; and col. 15, lines 10-38)*, wherein the first data is received from a fixed detector *(D1 and K1 of fig. 1; see D1 of fig. 2)* configured to detect the first data *(note the position and image of the natural object is considered as the first data, e.g. figs. 3a-d)* , and wherein the second data is received from a mobile target unit *(note the mobile camera is used; col. 12, lines 27-31; and col. 16, lines 10-38)* comprising a sensor *(a GPS is equipped with the mobile camera, col. 16, lines 11-20)* configured to detect the second data *(the position of natural object is determined by other means, col. 16, lines 12-20, the GSP is wirelessly connected to the position module M in figure 2)*; and,

a processor (Q and P of fig. 1) configured to correlate (1 and 2 of fig. 2) the first data *(the position of the natural object N is detected by the detector and camera, D1 and K1 of fig. 1)* and the second data *(the position of the natural object N is detected by the GPS, which is in a field of*

view of a camera as the mobile unit, col. 16, lines 11-20) to generate object location information *(e.g. figs. 9a, b, c, note the system for manipulating (4 of fig. 2) the picture of at least one movable, natural object in a natural television picture in such a manner that the object's position and movement are clearly visible in the television picture, col. 4, lines 51-63; wherein synthetic object represent position of the natural object any t time, which indicates the future position of the natural object).*

Moengen further teaches the object is a vehicle (a natural object would obviously considered a vehicle such as car race); and the mobile target unit *(e.g. mobile camera include GPS, col. 16, lines 11-20, the GPS is equipped with the natural object)* at least on of: mounted in the object, mounted on the object, carried in the object, or carried on the object (col. 10, lines 10-14).

Re claims 25 and 39, Moengen further teaches wherein the mobile target unit *(note the mobile camera, col. 16, lines 18-20)* comprises the communicator (Q of figs. 1 and 2) is further configured to receive the target unit location, the processor *(Q and P of fig. 1, the processing units 1-2 of fig. 2)* being further configured to determine whether the mobile target unit *(the mobile camera can be determined by the GPS)* is within a range of the fixed detector *(the mobile camera with the GPS within the field of view of a camera, e.g. K1, K2, or K3 of fig. 1; col. 16, lines 12-14).*

Re claim 26, Moengen further teaches the object location information comprises at least one of object trajectory information (fig. 9c, S(p0), S(p1), S(p2) and S(p3)), or object speed

information (col. 9, lines 3-8); and the fixed detector provides an image of the object (e.g. K1 of fig. 1).

Re claim 27, Moengen further teaches the object is a vehicle (a natural object would obviously be considered as a vehicle used in the car race event)*(e.g. mobile camera include GPS, col. 16, lines 11-20, the GPS is equipped with the natural object)*.

Re claim 28, Moengen further comprising a database *(Note pre-stored code sequences as position and image of the natural object is considered as database, col. 11, lines 30-35)* configured to maintain a plurality of current positions associated with at least one of a plurality of sensors (e.g D1 and D2 of fig. 1), a plurality of mobile target units (e.g. mobile cameras, col. 12, lines 28-31), or a plurality of objects (natural objects: N1 and N2).

Re claim 29, Moengen further teaches wherein the mobile target unit comprises an accelerometer *(T of fig. 2, note the active transponder also has to be mounted in the natural object, it has to be robust and capable of withstanding jolts and shocks as well as relative high accelerations)* configured to provide data indicative of movement of the object to facilitate generating the object location information (col. 10, lines 10-14).

Re claim 30, Moengen further teaches the object is an identified good *(Note the natural object N is broadly interpreted as an identified good such as foot ball, hand ball, tennis ball, golf ball, and ice hockey pucks)*; the mobile target unit *(the mobile camera, col. 15, lines 65-col. 16, lines 4)* comprises a radio-frequency identification device *(e.g. a wireless connection is inherently as a radio-frequency identification device, col. 16, lines 3-20);* and the fixed detector (D1 of fig. 1) comprises a camera (K1 of fig. 1) for observing the identified good (e.g. the natural object N is within the field of view of the camera K1 of fig. 1), to facilitate thereby enabling the

sensor *(e.g. GPS sensor is equipped into the mobile camera, col. 16, lines 12-20)* and the fixed detector *(note the mobile camera wirelessly communicates with the processing unit Q via data buses B, col. 16, lines 1-3)* to provide corroborative surveillance of the identified good (e.g. Q and P of fig. 1, see figs. 9a-c).

Re claim 32, Moengen teaches activating a second fixed detector (D2 and K2 of fig. 1) in response to the object location information (e.g. TK and D2 of fig. 1, processed by the processing unit, 1 and 2 of fig. 2).

Re claim 33, Moengen further teaches wherein the second data comprises an object identifier *(Note the synthetic object S can be represented with various attributes for size, shape and color, which is considered as an object identifier, col. 7, lines 37-47),* the method further comprising registering the object identifier (e.g. various attributes for size, shape and color of synthetic object S is pre-stored) in a database (e.g. Q and P of fig. 1) to indicate association with the object (figs. 9a-c).

Re claim 40, Moengen further teaches wherein the correlating the first data and the second data comprises determining compliance with a scheduled object activity (e.g. figs. 3a-4d, x, y, z, t).

Re claim 41, Moengen further teaches wherein the correlating the first data and the second data comprises determining a movement vector (col. 4, lines 26-49) to predict a future location of the object (not the speed, direction and the position of the natural object is shown on display, e.g. P of fig. 1, indicating the future location of the object).

Re claim 42, Moengen further teaches further comprising a plurality of detectors (TK, D1, K1; TK, D2, K2; and TK, D3, K3 of fig. 1, plurality cameras) each having a corresponding

observation range, wherein at least one of the plurality of detectors is selected to observe the object *(note a preselected x,y,z co-ordinate system at the time t, which means one of the camera is selected, K2 of fig. 1, see fig. 3b),* the fixed detector being selected in response to the processor's correlation of the first data and the second data *(e.g. 3 of fig. 2, camera control system based on the correlating performed by the processor, Q, 1, 2, and 4 of fig. 2).*

Re claim 43, Moengen further teaches wherein the first data comprises at least one of an image of the object (e.g. IK2 of fig. 3A) or an identifier associated with the object (D1 of fig. 1).

Re claim 44, Moengen further teaches wherein the first data comprises a plurality of images of the object captured at different times (IK2 of fig. 3A and I'K2 of fig. 3c).

Re claim 45, Moengen further teaches wherein the second data (e.g. K3 of fig. 1 as the mobile camera) comprises at least one of an image of the object (e.g. IK3 of fig. 4a) or an identifier associated with the object (D3 of fig.1, and GPS is equipped with the mobile camera).

Re claim 46, Moengen further teaches wherein the second data comprises a plurality of images of the object captured at different times (figs. 4a and 4c).

Re claim 47, Moengen further teaches wherein the object location information is determined at least in part based on a fixed detector location (VZ2, and V'Z2 of figs. 3a and 3c).

Re claim 48, Moengen further teaches wherein the object location information is determined at least in part based on a mobile target unit location (GPS system determines the location of the natural object).

Re claim 49, Moengen further teaches a movement module configured to activate a second fixed detector (e.g. TK, D2, K2 of fig. 1) in response to the object location information (1 and 2 of fig. 2).

Re claim 50, Moengen further teaches wherein the correlating the first data and the second data to generate the object location information comprises determining at least one of a trajectory or a speed of the object (col. 9, lines 3-7; col. 14, lines 33-36).

Re claim 51, Moengen further teaches wherein the mobile target unit comprises a locator unit configured to determine the target unit location mobile (a position of the mobile camera is determined by the GPS; col. 16, lines 11-17).

Re claim 52, Moengen further teaches wherein the fixed detector is configured to be selected in response to the processor's correlation of the first data and the second data processor's correlation of the first data and the second data (e.g. 3 of fig. 2, camera control system based on the correlating performed by the processor Q, l, 2, and 4 of fig. 2).

Re claim 53, Moengen further teaches wherein the fixed detector is further from the second fixed detector than from a third fixed detector (TK, D3, K3 of fig. 1).

4. Claim 41 is rejected under 35 U.S.C. 103(a) as being unpatentable over Everett, Jr. et al. (US 5,202,661) in view of Hyuga (US 5,818,733) and further in view of Kitamura et al. (5,554,983).

Re claim 41, Everett and Hyuga does not particularly disclose wherein the correlating the first data and the second data comprise determining a movement vector to predict a future location of the object as claimed.

Kitamura teaches wherein the correlating the first data and the second data (fig. 6) comprise determining a movement vector to predict a future location of the object (fig. 8).

Taking the teachings of Everett, Hyuga, and Kitamura as a whole, it would have been obvious to one to modify the teachings of Kitamura into the combined of Everett and Hyuga to reduce the processing time and accurately predict the object's position.

Response to Arguments

5. Applicant's arguments filed 07/36/2009 have been fully considered but they are not persuasive.

The applicant argued that Everett teaches against " wherein the mobile target unit is at least one of: mounted in the object, mounted on the object, carried in the object, or carried on the object" as amended in claim 1.

The examiner respectfully disagrees with the applicant. It is submitted that Everett teaches that the mobile target unit (18 of fig. 6) has the propulsion module (416 of fig. 6) for moving the mobile target unit (18 of fig. 6), and the propulsion module (426 of fig. 6) carried the camera and other elements as shown in figure 6, so this would obviously suggest that the mobile target unit includes a vehicle (416 and 422 of fig. 6) for the mobile target unit is mounted on in order to move the mobile unit.

Hyuga teaches the mobile target unit (1 of fig. 2) is at least one of: mounted in the object (a mobile unit carried by said sender or player or user), mounted on the object, carried in the object, or carried on the object (1 of fig. 2, the mobile unit can be hold by the golf player, fig. 4, and carried on the golf cart, 29 of fig. 2) and the object is a vehicle (the golf cart, 29 of fig. 2). With the suggested teachings of Everett and Hyuga, one skilled in the art would combine Everrett and Hyuga to make obvious claimed features to improve monitoring object.

The applicant further argues that Moengen does not disclose "a processor configured to correlate the first data and the second data to generate object location information" as claimed.

The examiner respectfully disagrees with the applicant. It is submitted that Moegen teaches a processor (Q and P of fig. 1) configured to correlate (1 and 2 of fig. 2) the first data (the position of the natural object N is detected by the detector and camera, D1 and K1 of fig. 1) and the second data (the position of the natural object N is detected by the GPS, which is in a field of view of a camera as the mobile unit, col. 16, lines 11-20) to generate object location information (e.g. figs. 9a, b, c, note the system for manipulating (4 of fig. 2) the picture of at least one movable, natural object in a natural television picture in such a manner that the object's position and movement are clearly visible in the television picture, col. 4, lines 51-63; wherein synthetic object represent position of the natural object any t time, which indicates the future position of the natural object). Note claim features do not include any image that is used to generate object location. Therefore, the disclosure of Moengen meets the claimed features.

Conclusion

THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37

CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Contact Information

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Tung Vo whose telephone number is 571-272-7340. The examiner can normally be reached on Monday-Wednesday, Friday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Mehrdad Dastouri can be reached on 571-272-7418. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Tung Vo/

Primary Examiner, Art Unit 2621

X. RELATED PROCEEDINGS APPENDIX

Copies of:

Amended Appeal Brief filed Nov. 17, 2006

Office Action dated Mar. 12, 2007 (reopening prosecution, no appeal instituted)

OIPE IAP98 NOV 17 2006 PATENT & TRADEMARK OFFICE

11-20-06

AF

Certificate of Mailing By "U.S. Certified Mail" Under 37 C.F.R. 1.8
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Name: Feng Elizondo
Signature

11/17/2006
Date

The Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

ATTN: Mail Stop Appeal Brief-Patents

Re: U.S. Utility Patent Application
Appl. No. **09/823,509** Filed **03/29/2001**
For: **Integrated Network for Monitoring Remote Objects**
Inventor(s): **Fernandez, et al.**
Docket No.: **FERN-P001C**

Sir:

The following documents are forwarded in response to the Notification of Non-Compliant Appeal Brief, dated 11/08/2006:

1. Copy of Notification of Non-Compliant Appeal Brief;
2. Amended Appeal Brief;
3. A return postcard.

It is respectfully requested that the attached postcard be stamped with the filing date of the above documents and returned to the addressee as soon as possible.

Applicants do not believe that any payment of fee is needed in association with this communication. However, should Applicants inadvertently miscalculated the required fee, the Commissioner is hereby authorized to charge any necessary amount associated with this communication or credit any overpayment to **Deposit Account No: 500482.**

Respectfully submitted,

11/17/2006
Date

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BOARD OF PATENT APPEALS AND INTERFERENCES

Inventors: Fernandez, et al.	Attorney Docket No.: FERN-P001C
Application No. 09/823,509	Examiner: Vo, Tung T
Filed: 03/29/2001	Art Unit: 2621
For: INTEGRATED NETWORK FOR MONITORING REMOTE OBJECTS	

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AMENDED APPEAL BRIEF IN SUPPORT OF APPELLANTS' APPEAL TO THE BOARD OF PATENT APPEALS AND INTERFERENCES

In reply to the Notification of Non-compliant Appeal Brief, mailed November 8, 2006, Appellants hereby submit the following Amended Appeal Brief pursuant to 37 CFR 41.37 in support of an appeal from the final rejection by the Examiner, dated May 24, 2006 and advisory action dated June 23, 2006, in the above-captioned case. Appellants filed a notice of appeal under § 41.31 on August 24, 2006. Also, Appellants assert that the following brief does not include any new or non-admitted amendment, affidavit, or other evidence. Appellants respectfully request consideration of this appeal by the Board of Patent Appeals and Interferences for allowance of the above-captioned patent application.

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A. The Examiner has clearly failed to provide a basis or rationale for the rejection of Claim 3, therefore Examiner has not established a *prima facie* case of obviousness under 35 U.S.C. 103(a).

B. The Examiner has not provided sufficient evidence of *prima facie* obviousness under §103(a) for the rejection of Claims 1-3, 5-12, 14-16, 18-21, and 23 as unpatentable over the prior art of Rauber in combination with Woolston.

C. The Examiner has made contradictory and incorrect statements and thus has improperly rejected claims 1-3, 5-12, 14-16, 18-21, and 23 under 35 U.S.C. 103(a) as being unpatentable over Rauber and Woolston.

D. Without establishing a *prima facie* case for the §103(a) obviousness combination of Rauber and Woolston, Examiner has not established that Claims 13, 17, and 22 are unpatentable over Rauber and Woolston in view of Durbin et al., and that Claim 4 is unpatentable in view of Kennedy.

VIII. ***Claims appendix*** 15

IX. ***Evidence appendix*** .... NONE

X. ***Related proceedings appendix*** .... NONE

I. Real party in interest

The real party in interest is Dennis Fernandez, an individual, having a residence at 1175 Osborn Avenue, Atherton, CA 94027.

II. Related appeals and interferences

Related proceedings to this application include US Patent Application No. 09/823,089 with Appeal Brief filed on June 12, 2006 and Application No. 09/823,508 with Notice of Appeal filed on October 11, 2006. To the best of Appellant's knowledge, there are no other prior or pending appeals, judicial proceedings or interferences known to the appellant which may be related to, directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

III. Status of Claims

In Examiner's Advisory Action Before the Filing of an Appeal Brief, mailed June 23, 2006, all claims 1-23 were **rejected**. Claims 1-23 are currently pending in this proceeding, Claims 1, 11 and 20 being independent claims. These pending claims, 1-23, are being appealed, and are appended herewith in the **Claims appendix**.

IV. Status of Amendments

In the Final Office Action mailed May 24, 2006, Examiner rejected claims 1-23. Subsequent to this final rejection, Applicant responded with an amendment filed June 2, 2006. Examiner **entered** the proposed amendments, in the Advisory Action mailed June

23, 2006, while affirming the rejection of claims 1-23. All pending claims 1-23 on appeal are provided in the **Claims appendix**, as filed in the June 2 amendment.

V. Summary of claimed subject matter

The subject matter of the invention, defined in independent claims 1, 11 and 20, is related to remote surveillance and communications technology, particularly to integrated fixed and mobile network electronics and related software for object attribute processing (see Appellant's Specification, page 1, lines 7-9; page 2, lines 19-20; and FIG. 1).

Specifically, the claimed subject matter pertains to goods inventory management (page 27, lines 19-27; FIG. 3, item 167 "Report") via the internet (page 9, lines 9-18) and through utilizing fixed detectors (page 6, lines 7-14; page 7, line 1-page 8, line 20; FIG. 1, item 3 "Detector;" page 34, lines 24-29; and page 35, lines 4-8) and mobile sensors (page 6, lines 7-14; page 34, lines 24-26; and page 35, lines 1-8). Monitored objects (page 3, lines 1-7 and 12-19; and FIG.1, item 2 "Object") are represented with a data structure (page 2, lines 11-13; and page 18, lines 25-30) comprising of 1) an object identifier (page 20, lines 7-17) representing one or more goods in production, inventory and shipment; 2) a first object location and time (page 22, lines 7-13), provided by a detector coupled to the console processing unit; and 3) a second object location and time, provided by a sensor coupled to the console processing unit. Additionally, the invention discloses a method (page 2, lines 28-29; FIG. 4; page 9, lines 9-18; page 29, lines 17-24; and page 30, lines 4-13) for processing such data structure and the utilization of a single-chip integrated circuit for doing so.

Security is addressed in the invention as an access means processes the data structure securely using a digital certificate (page 22, lines 15-23), watermark (page 8, lines 14-16) or encryption key (page 22, lines 15-17). This security feature assures that such data structure is accessible for object-monitoring from only one or more specified network site or processor. Control software is implemented in order to provide the data structure (page 2, lines 11-13) automatically and for network surveillance in response to user search query (page 11, lines 9-16; page 14, line 29-page 15, line 15; and page 31, line 12-18). Furthermore, such software is comprised of numerous components including a network and data communication module (page 14, line 22; and FIG. 3, item 161 "Communication"), an object and map database (page 14, lines 6-7; FIG. 3, item 162 "Database"; and page 18, lines 17-23) an object movement processing module (page 14, line 7, FIG. 3, item 163 "Movement"; and page 19, lines 12-29), a security management module (page 14, line 7; FIG. 3, item 164 "Security"; and page 22, line 15-page 23, line 8), an electronic transaction processing module (page 14, line 8; FIG. 3, item 165 "Transaction"; and page 23, line 25-page 25, line 11), a diagnosis tool (page 14, line 8; FIG. 3, item 166 "Diagnosis"; and page 26, lines 15-22), and a performance report updater module (page 14, lines 8-9; FIG. 3, item 167 "Report"; and page 27, line 19-page 28, line 2). Also included is a visual object analyzer module (page 14, line 9; FIG. 3, item 168 "Visual"; and page 28, lines 4-15) comprising a neural network or simulation program for recognizing adaptively one or more identified goods for real-time tracking of multiple goods movement, whereby such modules are functionally integrated to enable surveillance-based commercial transaction using the data structure (page 25, lines 13-28; and page 27, lines 1-7).

VI. Grounds of rejection to be reviewed on appeal

A. Whether claims 1-3, 5-12, 14-16, 18-21, and 23 are unpatentable under 35 U.S.C. 103(a) over Rauber et al. (US 6,182,053) in view of Woolston (US 5,845,265).

B. Whether claims 13, 17, and 22 are unpatentable under 35 U.S.C. 103(a) over Rauber et al. (US 6,182,053) in view of Woolston (US 5,845,265) as applied to claims 1, 11, and 20, and further in view of Durbin et al. (US 6,039,258).

C. Whether claim 4 is unpatentable under 35 U.S.C. 103(a) over Rauber et al. (US 6,182,053) in view of Woolston (US 5,845,265) as applied to claim 1, and in further view of Kennedy (US 6,301,480).

VII. Argument

A. The Examiner has clearly failed to provide a basis or rationale for the rejection of Claim 3, therefore Examiner has not established a *prima facie* case of obviousness under 35 U.S.C. 103(a).

In order to establish a *prima facie* case of obviousness, the prior art references when combined must teach or suggest all the claim limitations. *See*, MPEP 706.02(j). Examiner begins the rejection of Appellant's invention by concluding that claims 1-3, 5-12, 14-16, 18-21, and 23 are unpatentable under 35 U.S.C. 103(a) over Rauber et al. (US 6,182,053) in view of Woolston (US 5,845,265). Thereafter, Examiner states Appellant's claim language in each of said claims with reference to specific figures and text of Rauber and Woolston. However, Examiner has failed to indicate which prior art reference and more specifically, where in that reference the language of Claim 3 is

taught. Nowhere in Examiner's argument is there provided a reference to prior art which teaches, "a position signal being generated by the detector coupled to the monitored object when such object is moveable within an observable range, a visual signal being generated by the sensor uncoupled to such object in the observable range," (Appellant's Claim 3).

Where a reference is relied on to support a rejection, whether or not in a minor capacity, that reference should be positively included in the statement of the rejection. *In re Hoch*, 428 F.2d 1341, 1342 (C.C.P.A. 1970). Additionally, MPEP 706.02(j) sets forth the contents of an Examiner's 35 U.S.C. 103 rejection as including, "the relevant teachings of the prior art relied upon, preferably with reference to the relevant column or page number(s) and line number(s) where appropriate." In addressing Appellant's specific claim language that pertains to Rauber and similarly in addressing Appellant's specific claim language that pertains to Woolston, Examiner has failed to indicate the proper citation as to where the alleged §103(a) rejection of Claim 3 is based. MPEP 706.02(j) states that, "[i]t is important for an examiner to properly communicate the basis for a rejection so that the issues can be identified early and the applicant can be given a fair opportunity to reply."

Appellant argues that Examiner has provided no basis for rejection under §103(a) due to the failure to cite in the prior art references the alleged teaching of Claim 3's language. Examiner has merely asserted rejection of Claim 3. Therefore, without rationale for the §103(a) rejection of Claim 3, Examiner has not proven that the prior art references teach or suggest all the claim limitations under MPEP 706.02(j), and thus has failed to establish a *prima facie* case of obviousness.

B. **The Examiner has not provided sufficient evidence of *prima facie* obviousness under §103(a) for the rejection of Claims 1-3, 5-12, 14-16, 18-21, and 23 as unpatentable over the prior art of Rauber in combination with Woolston.**

On appeal to the Board, an applicant can overcome a rejection by showing insufficient evidence of *prima facie* obviousness. *In re Rouffett*, 149 F.3d 1350, 1355 (Fed. Cir. 1998). Examiner has argued that Claims 1-3, 5-12, 14-16, 18-21, and 23 are a combination of elements found in Rauber and Woolston. It is known that most, if not all, inventions are combinations and mostly of old elements. *Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 1540 (Fed. Cir. 1983). In demonstrating the combination, Examiner has merely identified relevant text and figures in both Rauber and Woolston that correspond to Appellant's Claim language. However, the court has held that mere identification of each element in the prior art is insufficient to defeat the patentability of the combined subject matter as a whole. *Rouffett*, 149 F.3d at 1355, 1357. To establish a *prima facie* case of obviousness based on a combination of elements disclosed in the prior art, the Examiner must articulate the basis on which it concludes that it would have been obvious to make the claimed invention. *Id.* Specifically, Examiner must "explain the reasons why one of ordinary skill in the art would have been motivated to select the references and to combine them to render the claimed invention obvious." *Id.* at 1359. In detail, this "motivation-suggestion-teaching" test asks not merely what the references disclose, but whether a person of ordinary skill in the art, possessed with the understandings and knowledge reflected in the prior art, and motivated by the general problem facing the inventor, would have been led to make the combination recited in the

claims. *See, Cross Med. Prods., Inc. v. Medtronic Sofamor Danek, Inc.*, 424 F.3d 1293, 1321-24 (Fed. Cir. 2005).

In order to find evidence of such motivation, suggestion or teaching, the court has recommended three places: 1) the content of the public prior art; 2) the nature of the problem addressed by the invention; or 3) the knowledge of one of ordinary skill in the art. *See, SIBA Neurosciences, Inc. v. Cadus Pharm. Corp.*, 225 F.3d 1349, 1356 (Fed. Cir. 2000). Examiner has presumably addressed the second place, the nature of the problem addressed by the invention. In determining whether the nature of the problem addressed by the invention supplies a motivation to combine certain prior art references, the court has engaged in a detailed analysis of the nature of the problem solved by the invention. *See, Princeton Biochemicals, Inc. v. Beckman Coulter, Inc.*, 411 F.3d 1332, 1338-39 (Fed. Cir. 2005). Here the Examiner has not even began to provided detailed analysis of the sort of problem addressed by Appellant's invention. Instead, Examiner briefly states that the alleged motivation to combine Rauber and Woolston by one of ordinary skill in the art would allow for, "observing goods with its price during inventory," and "allow the user to easily set up his or her own warehouse, store, or retailer for buying and selling goods via the Internet." In other words, Examiner is arguing that the nature problem addressed by Appellant's invention is the setting up of warehouses for internet sales and observing goods with price during inventory. Examiner argues the combination of Rauber and Woolston is motivated because it allows the user to "*easily* set up" such internet retail operations. Appellant argues that such reasoning is flawed.

First, Examiner misses the point of the nature of the problem addressed by Appellant's invention. In short, Appellant's invention deals with the problem of goods inventory management via the internet and through utilizing fixed detectors and mobile sensors, not the problem as stated by Examiner. Furthermore, if a person or ordinary skill in the art was faced with the problem as articulated by Examiner of setting up warehouses for internet sales with observation of goods with price during inventory, and that such person wanted to solve this problem "*easily*" as examiner states, they would not need to combine Rauber and Woolston. One would merely need to utilize the prior art as taught by the Woolston patent. In this patent, Woolston teaches a method for creating a "computerized market for used and collectible goods," i.e., Internet sales. Also, Woolston teaches a method to allow the "purchaser to change the price of the good once the purchases has purchased the good thereby to allow the purchaser to speculate on the price." In fact, this patent allowed Woolston to found the company MercExchange, L.L.C in 2001 and successfully commercialize this on-line auction technology. The Woolston patent essentially solved the problem of setting up warehouses for internet sales with observation of goods with price during inventory. Appellant stresses that Woolston was able to do this solely in reliance on his own patented invention and without the combination of the Rauber patent. Therefore, a person of ordinary skill in the art faced with the problem of "easily" setting up warehouses for internet sales with observation of goods with price during inventory would only need to utilize the Woolston patent.

Furthermore, Appellant argues that a person of ordinary skill in the art would not rely on the Rauber patent to solve such a problem. It has been long established by the

court that in order to be considered in a §103(a) obviousness analysis, prior art references must be analogous art. *See*, *Application of Antle*, 444 F.2d 1168 (C.C.P.A. 1971). The characteristic of being analogous refers to the prior art that courts deem, as a matter of law, a person having ordinary skill in the art would reasonably have consulted in solving the problem addressed by the claimed in invention. Rauber is non-analogous art to the problem, as articulated by Examiner, of "easily" setting up warehouses for internet sales with observation of goods with price during inventory. Rauber relates to managing distressed inventory, which is defined as inventory that is shipped by freight carriers which does not reach its intended destination, is not accepted by the buyer, accidentally loaded on the wrong freight truck, damaged, or simply marked improperly. Thus, it is evident that Rauber does not relate to the nature of the problem as articulated by Examiner. Therefore, Rauber is non-analogous prior art which does not address the particular problem of "easily" setting up warehouses for internet sales with observation of goods with price during inventory.

With only a need to utilize the Woolston patent to solve the nature of the problem as articulated by the Examiner, Appellant can find no teaching, suggestion or motivation to combine the prior art of Woolston with Rauber. Therefore, absent such findings, Appellant concludes that Examiner has stated insufficient evidence of *prima facie* obviousness of Claims 1-3, 5-12, 14-16, 18-21 and 23 under §103(a), and as such Appellant's application should be allowed.

C. The Examiner has made contradictory and incorrect statements and thus has improperly rejected claims 1-3, 5-12, 14-16, 18-21, and 23 under 35 U.S.C. 103(a) as being unpatentable over Rauber and Woolston.

The language of independent Claims 1, 11 and 20 state in part, "a first object location and time monitored at such location, the first object location being provided by a *detector*," (italics added). In addressing this language, Examiner cites Rauber (fig. 2, items 212-218) and states that the warehouse would obviously have a *detector* for detecting the first object.

First, Appellant presumes that Examiner is arguing that the warehouse inherently has a detector. If that is the case, Examiner cannot merely assert such an inherency determination. Rather, the examiner must provide a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic *necessarily* flows from the teachings of the applied prior art." *Ex parte Levy*, 17 U.S.P.Q.2d 1461, 1464 (Bd. Pat. App. & Inter. 1990). Examiner has not done so here and thus has incorrectly stated that such warehouse in Rauber would, "obviously have a detector."

Second, after stating that such detector is obvious in the warehouse of Rauber, Examiner then states, "[i]t is noted that Rauber *does not* particularly teach Internet and at least one fixed *detector*." Here Examiner has done an about face – first in stating that Rauber would obviously have a detector, and then stating that Rauber does not have such detector. These are contradictory statements.

Therefore, Appellant argues that Examiner has improperly rejected claims 1-3, 5-12, 14-16, 18-21, and 23 under 35 U.S.C. 103(a) as being unpatentable over Rauber and Woolston and as such Appellant's application should be allowed.

D. Without establishing a *prima facie* case for the §103(a) obviousness combination of Rauber and Woolston, Examiner has not established that Claims 13, 17, and 22 are unpatentable over Rauber and Woolston in view of Durbin et al., and that Claim 4 is unpatentable in view of Kennedy.

In rejecting claims 13, 17 and 22, Examiner relies on the combination of Rauber and Woolston with the prior art reference of Durbin et al. Appellant has previously argued, extensively, that there is no teaching, suggestion or motivation to combine the prior art of Woolston with Rauber, and thus Examiner has stated insufficient evidence for the *prima facie* obviousness combination of these prior art references under §103(a). Therefore, without a valid combination of Rauber and Woolston, Examiner's argument for rejecting Claims 13, 17 and 22 via incorporation of the teachings of Durbin into the combined system of Rauber and Woolston must fail. Similarly, with respect to Claim 4, Examiner's argument for the incorporation of the teachings of Kennedy into the system of Rauber and Woolston must also fail. In conclusion, claims 4, 13, 17 and 22 are patentable over the Rauber, Woolston, Durbin, and Kenney, and as such Appellant's application should be allowed..

CONCLUSION

For all of the reasons stated above, Appellant respectfully concludes that Examiner was in error to reject claims 1-3, 5-12, 14-16, 18-21, and 23 as being unpatentable over Rauber et al. (US 6,182,053) in view of Woolston (US 5,845,265) under 35 U.S.C. 103(a); Examiner was in error to reject claims 13, 17, and 22 as being unpatentable over Rauber in view of Woolston as applied to claims 1, 11, and 20, and in further view of Durbin et al. (US 6,039,265) under 35 U.S.C. 103(a); and Examiner was in error to reject claim 4 as being unpatentable over Rauber in view of Woolston as applied to claim 1, and in further view of Kennedy (US 6,301,480) under 35 U.S.C. 103(a). Therefore, Appellant prays for careful consideration of this appeal by the Board of Patent Appeals and Interferences in order for the ultimate allowance of all Claims 1-23.

Respectfully Submitted,

Date: 11/17/2006

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VIII. Claims appendix

<u>Claims Presented For Appeal</u>
<u>(as filed via Rule-116 Amendment dated June 2, 2006)</u>

1. (PREVIOUSLY PRESENTED) In a console processing unit for goods inventory management coupled via the Internet to at least one fixed detector and at least one mobile sensor, a data structure for representing a monitored object, the data structure comprising:

an object identifier, such object identifier representing one or more goods in production, inventory and shipment;

a first object location and a time monitored at such location, provided by a detector coupled to the console processing unit; and

a second object location and a time monitored at such location, provided by a sensor coupled to the console processing unit;

wherein an access means processes the data structure securely using a digital certificate, watermark or encryption key, such that the data structure is accessible for object-monitoring from only one or more specified network site or processor, the data structure being provided automatically using control software for network surveillance in response to a user search query, the software comprising a network and data communication module, an object and map database, an object movement processing module, a security management module, an electronic transaction processing module, a diagnosis tool, a performance report updater module, and a visual object analyzer module comprising a neural network or simulation program for recognizing adaptively one or more identified goods for real-time tracking of multiple goods movement, whereby such modules are

functionally integrated to enable surveillance-based commercial transaction using the data structure.

2. (PREVIOUSLY PRESENTED) The data structure of Claim 1 further comprising:

a scheduled object location and a time scheduled for such location.

3. (PREVIOUSLY PRESENTED) The data structure of Claim 1 wherein:

a position signal being generated by the detector coupled to the monitored object when such object is moveable within an observable range, a visual signal being generated by the sensor uncoupled to such object in the observable range.

4. (PREVIOUSLY PRESENTED) The data structure of Claim 1 wherein:

the detector comprises an accelerometer.

5. (PREVIOUSLY PRESENTED) The data structure of Claim 1 wherein:

a software agent associated with the monitored object accesses a database.

6. (PREVIOUSLY PRESENTED) The data structure of Claim 1 wherein:

the object identifier comprises an object name, an object group, an object query, an object condition, an object status, an object location, an object time, an object error, or an object image, video, or audio broadcast signal.

7. (PREVIOUSLY PRESENTED) The data structure of Claim 3 wherein:

the observable range is modifiable according to a rule set.

8. (PREVIOUSLY PRESENTED) The data structure of Claim 1 wherein:

the monitored object is monitored temporarily using an extrapolated or last-stored positional or visual signal.

9. (PREVIOUSLY PRESENTED) The data structure of Claim 1 wherein:

the monitored object is authenticated according to a voice pattern, a finger-print pattern, a handwritten signature, or a magnetic or smart-card signal.

10. (PREVIOUSLY PRESENTED) The data structure of Claim 1 wherein:

the monitored object is provided an electronic file comprising a book, a greeting card, a news report, a sports report, a stock report, an artwork, a research database, a personal list, a recorded or live voice or music transmission, an electronic tool, or a commercial transaction.

11. (PREVIOUSLY PRESENTED) In a console processing unit for goods inventory management coupled via the Internet to at least one fixed detector and at least one mobile sensor, a method for processing a data structure for representing a monitored object, the method comprising the step of:

transmitting to a processor in a network a data structure comprising an object identifier, such object identifier representing one or more goods in production,

inventory and shipment, a first object location and a time monitored at such location, the first object location being provided by a detector coupled to a console processing unit, and a second object location and a time monitored at such location, the second object location being provided by a sensor coupled to the console processing unit; wherein an access means processes the data structure securely using a digital certificate, watermark or encryption key, such that the data structure is accessible for object-monitoring from only one or more specified network site or processor, the data structure being provided automatically using control software for network surveillance in response to a user search query, the software comprising a network and data communication module, an object and map database, an object movement processing module, a security management module, an electronic transaction processing module, a diagnosis tool, a performance report updater module, and a visual object analyzer module comprising a neural network or simulation program for recognizing adaptively one or more identified goods for real-time tracking of multiple goods movement, whereby such one or more of such modules are functionally integrated to enable surveillance-based commercial transaction using the data structure.

12. (PREVIOUSLY PRESENTED) The data structure of Claim 1 wherein:

the sensor comprises a radio-frequency identification device for locating the identified goods, and the detector comprises a camera for observing such identified goods, thereby enabling the sensor and the detector to provide

corroborative surveillance of the identified goods within an observable range in which the sensor is mobile relative to the detector.

13. (PREVIOUSLY PRESENTED) The data structure of Claim 1 wherein:

the sensor comprises a sensor signal port for sensing a low-power or fuel condition of the identified goods, thereby enabling the console processing unit to indicate or warn a down period for using the identified goods.

14. (PREVIOUSLY PRESENTED) The data structure of Claim 1 wherein:

the detector comprises visual-analyzer means for recognizing adaptively the identified goods using a neural network or simulation program, thereby enabling secure inventory management of the identified goods.

15. (PREVIOUSLY PRESENTED) The data structure of Claim 1 wherein:

the data structure indicates in-stock availability of the identified goods for transacting shipment, and a tax-rate for transaction at the location of the identified goods.

16. (PREVIOUSLY PRESENTED) The method of Claim 11 wherein:

the sensor comprises a radio-frequency identification device for locating the identified goods, and the detector comprises a camera for observing such identified goods, thereby enabling the sensor and the detector to provide

corroborative surveillance of the identified goods within an observable range in which the sensor is mobile relative to the detector.

17. (PREVIOUSLY PRESENTED) The method of Claim 11 wherein:

the sensor comprises a sensor signal port for sensing a low-power or fuel condition of the identified goods, thereby enabling the console processing unit to indicate or warn a down period for using the identified goods.

18. (PREVIOUSLY PRESENTED) The method of Claim 11 wherein:

the detector comprises visual-analyzer means for recognizing adaptively the identified goods using a neural network or simulation program, thereby enabling secure inventory management of the identified goods.

19. (PREVIOUSLY PRESENTED) The method of Claim 11 wherein:

the data structure indicates in-stock availability of the identified goods for transacting shipment, and a tax-rate for transaction at the location of the identified goods.

20. (PREVIOUSLY PRESENTED) In a network for goods inventory management for coupling at least one fixed detector and at least one mobile sensor, a single-chip integrated circuit for processing a data structure for representing a monitored object, the circuit comprising:

a processor provided in a wireless target unit for transmitting or receiving in a network a data structure comprising an object identifier, such object identifier representing one or more goods in production, inventory and shipment, a first object location and a time monitored at such location, the first object location being provided by a detector, and a second object location and a time monitored at such location, the second object location being provided by a sensor; wherein an access means processes the data structure securely using a digital certificate, watermark or encryption key, such that the data structure is accessible for object-monitoring from only one or more specified network site or processor, the data structure being provided automatically using control software for network surveillance in response to a user search query, the software comprising a network and data communication module, an object and map database, an object movement processing module, a security management module, an electronic transaction processing module, a diagnosis tool, a performance report updater module, and a visual object analyzer module comprising a neural network or simulation program for recognizing adaptively one or more identified goods for real-time tracking of multiple goods movement, whereby one or more of such modules are functionally integrated to enable surveillance-based commercial transaction using the data structure.

21. (PREVIOUSLY PRESENTED) The circuit of Claim 20 wherein:

the sensor comprises a radio-frequency identification device for locating the identified goods, and the detector comprises a camera for observing such

identified goods, thereby enabling the sensor and the detector to provide corroborative surveillance of the identified goods within an observable range in which the sensor is mobile relative to the detector.

22. (PREVIOUSLY PRESENTED) The circuit of Claim 20 wherein:

the sensor comprises a sensor signal port for sensing a low-power or fuel condition of the identified goods, thereby enabling indication or warning of a down period for using the identified goods.

23. (PREVIOUSLY PRESENTED) The circuit of Claim 20 wherein:

the detector comprises visual-analyzer means for recognizing adaptively the identified goods using a neural network or simulation program, thereby enabling secure inventory management of the identified goods.

VIII. Evidence appendix

None.

X. Related proceedings appendix

None.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/823,509	03/29/2001	Dennis Sunga Fernandez	FERN-P001C	8530

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EXAMINER	

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ART UNIT	PAPER NUMBER

DATE MAILED: 11/08/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

RECD NOV 10 2006

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DATE 11/10/2006 FE

PTO-90C (Rev. 10/03)

Notification of Non-Compliant Appeal Brief (37 CFR 41.37)	Application No. 09/823,509	Applicant(s) FERNANDEZ ET AL.	
	Examiner Tung Vo	Art Unit 2621	

--The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

The Appeal Brief filed on 23 October 2006 is defective for failure to comply with one or more provisions of 37 CFR 41.37.

To avoid dismissal of the appeal, applicant must file anamended brief or other appropriate correction (see MPEP 1205.03) within **ONE MONTH or THIRTY DAYS** from the mailing date of this Notification, whichever is longer. **EXTENSIONS OF THIS TIME PERIOD MAY BE GRANTED UNDER 37 CFR 1.136.**

1. ☒ The brief does not contain the items required under 37 CFR 41.37(c), or the items are not under the proper heading or in the proper order.
2. ☐ The brief does not contain a statement of the status of all claims, (e.g., rejected, allowed, withdrawn, objected to, canceled), or does not identify the appealed claims (37 CFR 41.37(c)(1)(iii)).
3. ☐ At least one amendment has been filed subsequent to the final rejection, and the brief does not contain a statement of the status of each such amendment (37 CFR 41.37(c)(1)(iv)).
4. ☒ (a) The brief does not contain a concise explanation of the subject matter defined in each of the independent claims involved in the appeal, referring to the specification by page and line number and to the drawings, if any, by reference characters; and/or (b) the brief fails to: (1) identify, for each independent claim involved in the appeal and for each dependent claim argued separately, every means plus function and step plus function under 35 U.S.C. 112, sixth paragraph, and/or (2) set forth the structure, material, or acts described in the specification as corresponding to each claimed function with reference to the specification by page and line number, and to the drawings, if any, by reference characters (37 CFR 41.37(c)(1)(v)).
5. ☐ The brief does not contain a concise statement of each ground of rejection presented for review (37 CFR 41.37(c)(1)(vi))
6. ☐ The brief does not present an argument under a separate heading for each ground of rejection on appeal (37 CFR 41.37(c)(1)(vii)).
7. ☐ The brief does not contain a correct copy of the appealed claims as an appendix thereto (37 CFR 41.37(c)(1)(viii)).
8. ☐ The brief does not contain copies of the evidence submitted under 37 CFR 1.130, 1.131, or 1.132 or of any other evidence entered by the examiner **and relied upon by appellant in the appeal**, along with a statement setting forth where in the record that evidence was entered by the examiner, as an appendix thereto (37 CFR 41.37(c)(1)(ix)).
9. ☐ The brief does not contain copies of the decisions rendered by a court or the Board in the proceeding identified in the Related Appeals and Interferences section of the brief as an appendix thereto (37 CFR 41.37(c)(1)(x)).
10. ☒ Other (including any explanation in support of the above items):

The claimed invention is not mapped to independent claims 1,11 and 20, which shall refer to the specification by page and line number and to the drawings, if any .

Bridget C. Monroe

BRIDGET C. MONROE
PATENT APPEAL CENTER SPECIALIST

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09/823,509	03/29/2001	Dennis Sunga Fernandez	FERN-P001C	8530

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EXAMINER	
VO, TUNG T	
ART UNIT	**PAPER NUMBER**
2621	

SHORTENED STATUTORY PERIOD OF RESPONSE	MAIL DATE	DELIVERY MODE
3 MONTHS	03/12/2007	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

If NO period for reply is specified above, the maximum statutory period will apply and will expire 6 MONTHS from the mailing date of this communication.

Office Action Summary	Application No.	Applicant(s)	
	09/823,509	FERNANDEZ ET AL.	
	Examiner	Art Unit	
	Tung Vo	2621	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 03 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-23 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1-23 is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Reopen Prosecution

In view of the appeal brief filed on 11/17/2006, and the appeal conference with supervisors, Mehrdad Dastouri and Thai Tran, and the examiner, Tung Vo, on 02/27/2007, PROSECUTION IS HEREBY REOPENED. The office action is set forth below.

To avoid abandonment of the application, appellant must exercise one of the following two options:

(1) file a reply under 37 CFR 1.111 (if this Office action is non-final) or a reply under 37 CFR 1.113 (if this Office action is final); or,

(2) initiate a new appeal by filing a notice of appeal under 37 CFR 41.31 followed by an appeal brief under 37 CFR 41.37. The previously paid notice of appeal fee and appeal brief fee can be applied to the new appeal. If, however, the appeal fees set forth in 37 CFR 41.20 have been increased since they were previously paid, then appellant must pay the difference between the increased fees and the amount previously paid.

A Supervisory Patent Examiner (SPE) has approved of reopening prosecution by signing below:

Mehrdad Dastouri
MEHRDAD DASTOURI
SUPERVISORY PATENT EXAMINER
TC 2600

It is noted that that claims 1-10, and 12-15 are rejected under 35 U.S.C. 101, and claims 1-23 are rejected as follows.

Claim Rejections - 35 USC § 101

1. 35 U.S.C. 101 reads as follows:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.
>
> Descriptive material can be characterized as either "functional descriptive material" or "nonfunctional descriptive material." In this context, "functional descriptive material" consists of data structures and computer programs which impart functionality when employed as a computer component. (The definition of "data structure" is "a physical or logical relationship among data elements, designed to support specific data manipulation functions." The New IEEE Standard Dictionary of Electrical and Electronics Terms 308 (5th ed. 1993).) "Nonfunctional descriptive material" includes but is not limited to music, literary works and a compilation or mere arrangement of data.
>
> When functional descriptive material is recorded on some computer-readable medium it becomes structurally and functionally interrelated to the medium and will be statutory in most cases since use of technology permits the function of the descriptive material to be realized. Compare In re Lowry, 32 F.3d 1579, 1583-84, 32 USPQ2d 1031, 1035 (Fed. Cir. 1994) (claim to data structure stored on a computer readable medium that increases computer efficiency held statutory) and Warmerdam, 33 F.3d at 1360-61, 31 USPQ2d at 1759 (claim to computer having a specific data structure stored in memory held statutory product-by-process claim) with Warmerdam, 33 F.3d at 1361, 31 USPQ2d at 1760 (claim to a data structure per se held nonstatutory).
>
> In contrast, a claimed computer-readable medium encoded with a computer program is a computer element which defines structural and functional interrelationships between the computer program and the rest of the computer which permit the computer program's functionality to be realized, and is thus statutory. See Lowry, 32 F.3d at 1583-84, 32 USPQ2d at 1035.

2. Claims 1-10 and 12-15 are rejected under 35 U.S.C. 101 because the claimed invention is directed to non-statutory subject matter as follows. Claim 1 defines in a console processing unit for goods inventory management coupled via the Internet to at least one fixed detector and at least one mobile sensor, a data structure for representing a monitored object, the data structure comprising embodying functional descriptive material. However, the claim does not define a computer-readable medium or memory and is thus non-statutory for that reason (i.e., "When functional descriptive material is recorded on some computer-readable medium it becomes structurally and functionally interrelated to the medium and will be statutory in most cases since use of technology permits the function of the descriptive material to be realized" - Guidelines Annex IV). That is, the scope of the presently claimed data structure can range from paper on

which the program is written, to a program simply contemplated and memorized by a person. The examiner suggests amending the claim to embody the program on "computer-readable medium" or equivalent in order to make the claim statutory. Any amendment to the claim should be commensurate with its corresponding disclosure.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 1-3, 5-12, 14-16, 18-21, and 23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Rauber et al (US 6,182,053) in view of Woolston (US 5,845,265).

Re claims 1, 3, 5, 7, 11-12, 14, 16, 18, 20-21, and 23, Rauber teaches in a console processing unit (12 of fig. 1) for goods inventory management coupled via LOCAL-AREA-NETWORK (LAN) connection, at least one mobile sensor (16 of fig. 1),

a data structure for representing a monitored object (freight), the data structure a processor (12 of fig. 1) provided in a wireless target unit (16 of fig. 1; 18 of fig. 1) for transmitting or receiving in a network a data structure (LAN), comprising: an object identifier (12 of fig. 1; see also 302-308 of fig. 3) representing one or more goods in production, inventory and shipment (col. 7, lines 1-63); a first object location and a time monitored at such location (212-218 of fig. 2; Note the warehouse would obviously have a detector for detecting the first object (good, product, merchandize)), provided by a detector coupled to the console processing

unit (12 of fig. 1); and a second object location and a time monitored at such location (220 of fig. 2, Note the retail store would obviously have scanner for scanning the second object (good, product, merchandize)), provided by a sensor coupled to the console processing unit (12 of fig. 1); wherein an access means (12 or 18 of fig. 1; Col. 8, lines 6-13) processes the data structure securely using a digital certificate, watermark or encryption key (Note enter his or her salesperson ID number and customer ID number), such that the data structure is accessible for object-monitoring from only one or more specified network site (12, 18 of fig. 1) or processors the data structure being provided automatically using control software (fig. 2) for network surveillance in response to a user search query (col. 8, lines 29-44); the software (fig. 2) comprising: a network and data communication module (col. 8, lines 45-52; Note any of the RF unites would be used to communicate for the inventory method); an object and map database (col. 7, lines 30-36); an object movement processing module (308 of fig. 3; Note updating the object location; where in step 308, the computer program prompts the operator to enter the location within the distressed inventory warehouse where the inventory will be initially stored before it proceeds through further stages of the inventory management method. As described in more detail below, this location may include a warehouse area, a retail area, or other specialized areas for particular types of freight);

a security management module (col. 8, lines 6-13); an electronic transaction processing modules (col. 8, lines 53-61); a diagnosis tool (504 of fig. 5); a performance report updater modules (508 of fig. 1); and a visual object analyzer module (col. 8, lines 62-67); whereby such modules are functionally integrated to enable surveillance-based commercial transaction using the data structure (figs. 1 and 2); wherein the sensor (16 of fig. 1) comprises a radio-frequency

identification device for locating the identified goods (16 of fig. 1); wherein a neural network or simulation program for recognizing adaptively on or more identified goods for real-time tracking a multiple goods movement (col. 10, lines 5-28, Note the inventory management would recognized the multiple goods that have been selling from one of the PGU's, where the inventory management would obviously determines how many items that are available in the warehouse and in the store, e.g. Wal-mart, using dual two-gigar byte mirroring hard drives, and an integrated local-area-network (LAN) connection with the host computer (12 of fig. 1) may be any type of computer including a microcomputer, minicomputer, or mainframe computer).

It is noted that Rauber does not particularly teach Internet and at least one fixed detector that comprises a camera for observing such identified goods, thereby enabling the sensor and the detector to provide surveillance of the identified goods within an observable range in which the sensor is mobile relative to the detector; the detector comprises visual-analyzer means for recognizing adaptively the identified goods using a neural network or simulation program, thereby enabling secure inventory management of the identified goods as claimed.

However, Rauber suggests that equivalents may be employed and substitutions made herein, so this is evidence to one skilled in the art to modify any conventional and suitable devices and methods to the Rauber's system.

Woolston teaches Internet (col. 14, lines 51-63) and at least one fixed detector (12 of fig. 1) that comprises a camera (12 of fig. 1) for observing such identified goods, thereby enabling the sensor (14 of fig. 1) and the detector (12 of fig. 1) to provide surveillance of the identified goods within an observable range (the camera 12 of figure 1 is able to capturing the goods within an observation range) in which the sensor (14 of fig. 1) is mobile relative to the detector; the

detector comprises visual-analyzer means (920 of fig. 13, viewing goods) for recognizing adaptively the identified goods using a neural network or simulation program (the image is generated by the camera (12 of fig. 1) and is displaying on the display (16 or 28 of fig. 1)), thereby enabling secure inventory management of the identified goods (804 of fig. 8; Note it is understood that a secure and/or encrypted means may be established between a participant's interface application and a consignment node to transfer sensitive or theft prone information); a software agent (the computer (10 of fig. 1) would obviously have a software agent associated with the monitored object for accessing a database (10 of fig. 1, database for accessing network)); the observable range is modifiable according to a rule set (far or near the camera (12 of fig. 1)), wherein network is used for the inventory management is provided (fig. 1) and tracking down where the items or goods are located for inventory (the operation would obviously track or view the goods for inventory).

Therefore, taking the teachings of Rauber and Woolston as a whole, it would have been obvious to one of ordinary skill in the art to incorporate the teachings of Woolston into the console processing unit of Rauber for observing goods with its price during inventory. Doing would allow the user to easily set up his or her own warehouse, store, or retailer for buying and selling goods via the Internet.

Re claim 2, Rauber further teaches a scheduled object location and a time scheduled for such location (col. 7, lines 49-63).

Re claim 6, Rauder further teaches the object identifier (12 of fig. 1) comprises an object name, an object group, an object query, an object condition, an object status, an object location, an object time, an object error, or an object image, video, or audio broadcast signal.

Re claim 8, Rauber further teaches the monitored object is monitored temporarily using an extrapolated or last-stored positional or visual signal (506 of fig. 5).

Re claim 9, Rauber further teaches the monitored object is authenticated according to a voice pattern, a finger-print pattern, a handwritten signature, or a magnetic or smart-card signal (fig. 4, ID salesman).

Re claim 10, Rauber further teaches the monitored object is provided an electronic file comprising a book, a greeting card, a news report, a sports report, a stock report, an artwork, a research database, a personal list, a recorded or live voice or music transmission, an electronic tool, or a commercial transaction (224, 226, and 228 of fig. 2).

Re claims 15 and 19, Rauber further teaches the data structure indicates in-stock availability of the identified goods for transacting shipment (fig. 3), and a tax-rate for transaction at the location of the identified goods (426 of fig. 4).

5. Claims 13, 17, and 22 are rejected under 35 U.S.C. 103(a) as being unpatentable over Rauber et al (US 6,182,053) in view of Woolston (US 5,845,265) as applied to claims 1, 11, and 20, and further in view of Durbin et al. (US 6,039,258).

Re claims 13, 17, and 22, the combination of Rauber and Woolston teaches the sensor is mobile in the observation range except a sensor signal port for sensing a low-power or fuel condition of the identified goods, thereby enabling the console processing unit to indicate or warm a down period for using the identified goods as claimed.

Durbin teaches a sensor signal port for sensing a low-power or fuel condition of the identified goods, thereby enabling the console processing unit to indicate or warm a down period

for using the identified goods (14 of fig. 1; Note the somatic communication system 14 may be utilized to indicate when the battery level is low, when there is a system error in the operating system, and other various alarm type of signals).

Therefore, taking the teachings of Rauber, Woolston, and Durbin as a whole, it would have been obvious to one of ordinary skill in the art to incorporate the teachings of Durbin into the combined system of Rauber and Woolston for recognizing the low power or battery of the sensor as suggested by Durbin (14 of fig. 1). Doing so would allow the user to change or recharge the battery in advance to prevent damage of the handheld or portable sensor.

1. Claim 4 is rejected under 35 U.S.C. 103(a) as being unpatentable over Rauber et al (US 6,182,053) in view of Woolston (US 5,845,265) as applied to claim 1, and further in view of Kennedy (US 6,301,480).

Re claim 4, the combination of Rauber and Woolston does not particularly teach the detector comprises an accelerometer as claimed.

However, Kennedy teaches a mobile communication unit (12 of fig. 1) comprises an accelerometer and personal health sensor (col. 3, lines 5-19).

Therefore, taking the combined teachings of Rauber, Woolston and Kennedy as a whole, it would have been obvious to one of ordinary skill in the art to incorporate the teachings of Kennedy into the system of the combined system of Rauber and Woolston for the same purpose of communicating between the remote buyer and central station fast and more accuracy. Doing so would provide the advantages of the system include the adaptation of the system to provide mobile units are associated with cars, trucks, boats, barges, airplanes, cargo holders,

persons or other mobile items such as ambulance vehicle that desire a selection of services. These services include emergency services, roadside assistance, information services (e.g., directions, news and weather reports, financial quotes, etc.), or other as suggested by Kennedy.

Conclusion

2. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Odom et al (US 6,058,379) discloses real-time network exchange with seller specified exchange parameters and interactive seller.

Contact Information

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Tung Vo whose telephone number is 571-272-7340. The examiner can normally be reached on Monday-Friday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Mehrdad Dastouri can be reached on 571-272-7418. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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